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PATENT #11

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of: **TIMOTHY J. YOUNG, LARRY T. SCHLITZER, KEVIN E. YOUSEY, KEVIN S. REITTER**

Docket No.: 10030

Serial No.: **09/772,177**

Art Unit: 3654

Filed: 01/29/2001

Examiner: Minh Chau Pham

For: WEB TRACKING ADJUSTMENT DEVICE AND METHOD THROUGH USE OF A BIASED GIMBAL

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Kathleen K. Bowen
Kathleen K. Bowen

7/21/2003
Date of Signature

BRIEF FOR APPELLANT

Sir:

This brief is filed in support of the Notice of Appeal filed on May 21, 2003. This brief is in support of an appeal from the final action of the Primary Examiner mailed November 25, 2002, and the subsequent Advisory Action mailed March 18, 2003.

I. THE REAL PARTY IN INTEREST

The real parties in interest are Heidelberg Digital, L.L.C., assignee of this application, and Heidelberger Druckmaschinen AG.

II. RELATED APPEALS AND INTERFERENCES

Appellant believes there are no related interferences or appeals that will have any bearing on this appeal.

III. STATUS OF THE CLAIMS

Claims 1-20 are pending in the application; claims 3-7, 10-15, 19, and 20 are allowed, and claims 1, 2, 8, 9, and 16-18 have been rejected. Appeal is taken on the rejected claims.

IV. STATUS OF THE AMENDMENTS

Claims 3, 4, 11, 15, and 19 have been amended once to make them independent claims. Claims 7, 10, and 20 have been amended twice, first to correct an antecedent basis issue, and secondly to make them independent claims. Claims 9, 16, and 17 have been amended once to correct clerical errors. These changes did not include any new matter, and in no way changed the scope of the claims. All amendments were entered by the Examiner. The appealed claims are included in Appendix A of this brief.

V. SUMMARY OF THE INVENTION AND ITS ILLUSTRATIVE EMBODIMENT

In high speed electrostatographic reproduction apparatus, it is a common practice to employ an elongated photoconductive belt or web adapted to record transferable images while the web is moving in a path in operative relation with various process stations. Typically the web is supported by, and driven about, at least one roller. With a roller support, there is a tendency for the moving web to shift laterally, or cross-track, with respect to such a roller. Electrostatographic reproduction apparatus therefore typically utilize servo-actuated or self-actuated steering rollers. While such steering rollers generally correct in a gross manner the cross-track shifting of the web, they tend to produce significant lateral movement of the web at an uneven rate as it is re-aligned.

In a closed loop web/roller system **8**, at least one steering roller **10** is provided; that is the roller which is free to move in some fashion so as to "steer" the web laterally

(parallel to the steering roller **10** longitudinal axis **9**) to bring it to the desired position. One way in which a roller may move is by "gimballing" the roller; i.e. by mounting the roller for pivotal movement about a gimbal axis **6**, which is parallel to the direction of linear movement of the entering web, and which preferably intersects the longitudinal axis **9** of the roller at the midpoint of the roller.

Another way in which a roller may move is by mounting the roller for pivotal movement about a caster axis **7**, which is an axis perpendicular to the gimbal axis, which intersects the gimbal axis **6** upstream of the roller. A roller may be both "castered" and "gimbaled", which means that such a roller is able to pivot about both the caster axis **7** and the gimbal axis **6**.

According to an aspect of the invention, a method of web tracking adjustment for guiding a moving web **2** in a predetermined path of travel relative to a stationary frame **4** comprises biasing a steering roller **10** in a gimbal direction, and adjusting the bias to achieve desired tracking. By biasing the steering roller **10** in a gimbal direction it is meant that the steering roller is pivoted about the gimbal axis **6** such that the web **2** on the downstream side of the steering roller **10** is not perpendicular to the longitudinal axis **9** of the steering roller **10**. This can be seen in Figure 2, which is a top view of the web/roller system **8**, laid out flat for viewing purposes.

In a preferred embodiment, the steering roller **10** is biased by a spring **20** having an end one **22** and an end two **24** mounted between the frame **4** and one end of the steering roller **10** such that the spring end one **22** is mounted to the frame **4**, and the spring end two **24** is mounted to the steering roller **10**, such that the spring **20** applies a rotational force on the steering roller **10** about a gimbal axis **6**. According to an aspect of the invention, a means for adjustment is accomplished by applying a pre-load to the spring **20** to achieve the desired tracking. One method for applying this pre-load is by attaching a mounting nut **26** to the spring end one **22**, and threading a mounting screw **28** through the frame **4**, such that the mounting nut **26** is threaded onto the mounting screw **28** to apply the desired pre-load on said spring.

VI. ISSUES ON APPEAL

A) The non-anticipation of claims 1, 2, 9, and 16-18, by Moe et al.

B) The non-anticipation of claims 1 and 8 by Morse (USP 3,913,813).

C) The non-anticipation of claims 1 and 8 by Morse et al (USP 3,608,796).

VII. THE ART RELIED ON BY THE EXAMINER

Moe et al	USP 5,659,851	8/19/1997
Morse	USP 3,913,813	10/21/1975
Morse et al	USP 3,608,796	9/28/1971

VIII. GROUPING OF THE CLAIMS

Claims 1, 2, 9, and 16-18 have been rejected under 35 U.S.C. 102 as being anticipated by Moe et al. Claims 1 and 8 have been rejected under 35 U.S.C. 102 as being anticipated by Morse (USP 3,913,813). Claims 1 and 8 have been rejected under 35 U.S.C. 102 as being anticipated by Morse et al (USP 3,608,796). As described in the arguments below, Appellant considers each of these claims to be separately patentable. Appellant requests that the claims be considered individually.

IX. APELLANT'S ARGUMENTS

A) THE NON-ANTICIPATION OF CLAIMS 1, 2, 9, and 16-18, BY Moe et al.

Claims 1, 2, 9, and 16-18 stand rejected under 35 U.S.C. 102 as being anticipated by Moe et al. With respect to claims 1, 2, 17, and 18, applicants respectfully requested the Examiner identify where Moe et al discloses "A method of web tracking adjustment for guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising: biasing a steering roller in a gimbal direction;

and, adjusting said bias to achieve desired tracking" (applicant's claim 1) so applicants could adequately respond. The Examiner responded by stating that "Moe et al (US 5,659,851) discloses biasing the steering roller (14) in the gimbal direction (56) through the use of springs (80). " The axis (56) of Moe et al. is not the gimbal direction. Moe et al. calls it the "steering axis 56", which corresponds to the "gimbal axis" of the captioned application. Applicants respectfully submit that the Examiner's construction of Moe et al. is in error. Further, the springs (80) of Moe et al are repeatedly referred to as "pivot resisting means" (column 7, lines 3-5, and lines 46-47) which are there to *resist* bias, not to *cause* bias. Therefore, since Moe et al does not disclose this limitation, appellant requests reversal of the Examiner regarding rejection of claims 1, 2,17, and 18.

Examiner further states that Moe et al discloses "a means for adjusting (94)(96)", but applicant's claim requires "adjusting said bias to achieve desired tracking." Examiner has not shown that (94) and (96) adjust the bias to achieve desired tracking. Moe et al. describes item (94) as "a tension adjusting disc (94)" and item (96) as a "tension releasing cam (96)" [column 8, lines 28-29]. These are used "to quickly engage or release the tension applied by the coil spring (88)" which "biases the carriage pin toward the steering roller" (column 8 lines 30-40). This is a force along the gimbal axis, which does **not** cause bias in the gimbal direction. As defined, by biasing the steering roller **10** in a gimbal direction it is meant that the steering roller is pivoted about the gimbal axis **6** such that the web **2** on the downstream side of the steering roller **10** is not perpendicular to the longitudinal axis **9** of the steering roller **10**. "A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described in a single prior art reference" [MPEP 2131 quoting *Verdegaal Bros. v. Union Oil Co. of California,* 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). Therefore, since Moe et al does not disclose this limitation, appellant requests reversal of the Examiner regarding rejection of claims 1, 2,17, and 18.

With regard to claims 2 and 18, Moe et al does not disclose "a lateral constraint" wherein the bias "allows the web to ride against said lateral constraint without damaging

the web." Therefore, since Moe et al does not disclose this limitation, appellant requests reversal of the Examiner regarding rejection of claims 2 and 18 on this basis.

With regard to claims 9 and 16, applicants respectfully requested that Examiner identify where Moe et al discloses "a gimbaled steering roller having a lateral constraint; a means for biasing said steering roller in a gimbal direction; and, a means for adjusting said bias to achieve desired tracking" so applicants could adequately respond. Examiner responded by stating that Moe et al disclosed a "means for biasing (80) in a gimbal direction (56); a means for adjusting (94)(96)." However, as stated above, the axis (56) of Moe et al. is not the gimbal direction. Moe et al. calls it the "steering axis 56", which corresponds to the "gimbal axis" of the captioned application. Further, flat springs (80) are not a means for biasing, but rather a means for resisting bias. Further, as stated above, items (94) and (96) are not "means for adjusting said bias to achieve desired tracking." Therefore, since Moe et al does not disclose these limitations, appellant requests reversal of the Examiner regarding rejection of claims 9 and 16.

B) THE NON-ANTICIPATION OF CLAIMS 1 and 8 by Morse (USP 3,913,813).

Claims 1 and 8 stand rejected under 35 U.S.C. 102 (b) as being anticipated by Morse. (3,913,813). Examiner states that Morse discloses "biasing the steering roller (11) in the gimbal direction (20) through the use of resilient wire (61)." The axis (20) of Morse is not the gimbal direction. Morse refers to (20) as a "gimbal axis." Applicants respectfully submit that the Examiner's construction of Morse (3,913,813) is in error. Further, resilient wire (61) does not bias a steering roller in a gimbal direction, but constrains the roller to reduce the freedom of movement to "pivotal movement about gimbal axis (20) and castering axis (30)" (column 6, lines 15-23). Therefore, since Morse (USP 3,913,813) does not disclose this limitation, appellant requests reversal of the Examiner regarding rejection of claims 1 and 8 on this basis.

The Examiner furthers states that Morse (3,913,813) discloses "adjusting the bias (60)(70)(72)". However, the yoke/screw assembly (70)(72) in Morse results in a force about the caster axis (30), not the gimbal axis (20) (see Figures 2a and 2b). Therefore, since Morse (USP 3,913,813) does not disclose this limitation, appellant requests reversal of the Examiner regarding rejection of claims 1 and 8 on this basis.

C) THE NON-ANTICIPATION OF CLAIMS 1 and 8 by Morse et al (USP 3,608,796).

Claims 1 and 8 stand rejected under 35 U.S.C. 102(b) as being anticipated by Morse et al (3,608,796). Examiner states that Morse et al discloses "biasing the steering roller (2) in the gimbal direction (34) through the use of flexure arm (40) and the U-shaped spring bracket 52." The axis (34) of Morse et al is not the gimbal direction. Morse et al refers to (34) as a "gimbal axis." Further, flexure arm (40) is used to "adjustably position the roller about axis **32**" (column 2, lines 68-69), which is the caster axis. The U-shaped bracket (52) "exerts a force on flexure **40** in the direction of arrow **54**" (column 3 lines 11-12). A force in the direction (54) would cause movement about the caster axis (32), not the gimbal axis (34) (see Figure 1). Therefore, since Morse et al (USP 3,608,796) does not disclose this limitation, appellant requests reversal of the Examiner regarding rejection of claims 1 and 8 on this basis.

Examiner further states Morse et al discloses "adjusting the bias (36)(44)(46)." The adjustment features Examiner refers to (36)(44)(46) are to position the roller (2) about the adjustment axis (32) (see column 2 lines 59-70), not the gimbal axis. "A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described in a single prior art reference" [MPEP 2131 quoting *Verdegaal Bros. v. Union Oil Co. of California,* 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). Therefore, since Morse et al (USP 3,608,796) does not disclose this limitation, appellant requests reversal of the Examiner regarding rejection of claims 1 and 8 on this basis.

IX. SUMMARY

Appellant's claimed Web tracking adjustment device and method through use of a biased gimbal as described in claims 1, 2, 8, 9, and 16-18 is distinct and patentably defined over the cited references as applied by the Examiner. Appellant requests reversal of the final rejection of Claims 1, 2, 8, 9, and 16-18.

Respectfully submitted,

Kathleen K. Bowen
Attorney for Appellant
Reg. No. 42,352
(330) 945-6931

Date: 7/21/03

APPENDIX A

1. A method of web tracking adjustment for guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

biasing a steering roller in a gimbal direction; and,

adjusting said bias to achieve desired tracking.

2. The method of claim 1 wherein said steering roller has a lateral constraint, and said bias allows the web to ride against said lateral constraint without damaging the web.

8. The method of claim 1 wherein said steering roller is mounted to said stationary frame in such a manner as to allow said steering roller to pivot about a caster axis.

9. (once amended) A web tracking apparatus for guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

a gimbaled steering roller having a lateral constraint;

a means for biasing said steering roller in a gimbal direction; and,

a means for adjusting said bias to achieve desired tracking.

16. (once amended) The web tracking apparatus of claim 9 further comprising a stop for preventing said steering roller from rotating too far in the gimbal direction.

17. (once amended) A method of web tracking adjustment for guiding a photoconductor loop in a electrostatographic reproduction apparatus on a predetermined path of travel relative to a stationary frame, comprising:

biasing a steering roller in a gimbal direction; and,

adjusting said bias to achieve desired tracking.

18. The method of claim 17 wherein said steering roller has a lateral constraint, and said bias allows the web to ride against said lateral constraint without damaging the web.

TABLE OF CONTENTS FOR APPENDICIES

APPENDIX B

1. A method of web tracking adjustment for guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

biasing a steering roller in a gimbal direction; and,

adjusting said bias to achieve desired tracking.

2. The method of claim 1 wherein said steering roller has a lateral constraint, and said bias allows the web to ride against said lateral constraint without damaging the web.

3. (once amended) A method of web tracking adjustment for guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

biasing a steering roller in a gimbal direction wherein said bias allows the web to ride against a lateral constraint without damaging the web, and wherein said steering roller is mounted on a roller shaft, and said lateral constraint comprises an edge guide which is rotatably mounted on said roller shaft and is axially slidable relative thereto; and,

adjusting said bias to achieve desired tracking.

4. (once amended) A method of web tracking adjustment for guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

biasing a steering roller in a gimbal direction wherein said bias allows the web to ride against a lateral constraint without damaging the web, wherein said steering roller is biased by a spring having an end one and an end two mounted between the frame and one end of said steering roller such that said spring end one is mounted to said frame, and said spring end two is mounted to said steering roller, such that said spring applies a rotational force on said steering roller about a gimbal axis; and,

adjusting said bias to achieve desired tracking.

5. The method of claim 4 wherein said adjustment comprises applying a pre-load to said spring to achieve desired tracking.

6. The method of claim 5 wherein said spring is mounted to said frame by attaching a mounting nut to said spring end one, and threading a screw through

the frame, such that said mounting nut is threaded onto said screw to apply the desired pre-load on said spring.

7. (twice amended) A method of web tracking adjustment for guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

biasing a steering roller in a gimbal direction;

adjusting said bias to achieve desired tracking, and further comprising a housing and spring flexures, wherein said housing is pivotally mounted to said frame such that said housing pivots about a gimbal axis, and wherein said steering roller is mounted on a roller shaft, which said shaft is in turn mounted to said housing by said spring flexures, such that said spring flexures allow said steering roller to pivot about a caster axis, while said housing allows said steering roller to pivot about a gimbal axis.

8. The method of claim 1 wherein said steering roller is mounted to said stationary frame in such a manner as to allow said steering roller to pivot about a caster axis.

9. (once amended) A web tracking apparatus for guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

a gimbaled steering roller having a lateral constraint;

a means for biasing said steering roller in a gimbal direction; and,

a means for adjusting said bias to achieve desired tracking.

10. (twice amended) A web tracking apparatus for a guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

a gimbaled steering roller having a lateral constraint;

a means for biasing said steering roller in a gimbal direction; and,

a means for adjusting said bias to achieve desired tracking, and further comprising a housing and spring flexures, wherein said housing is pivotally mounted to said frame such that said housing pivots about a gimbal axis of said steering roller, and wherein said steering roller is mounted on a roller shaft, which said shaft is in turn mounted to said housing by said spring flexures, such that

said spring flexures allow said steering roller to pivot about a caster axis, while said housing allows said steering roller to pivot about a gimbal axis.

11. (once amended) A web tracking apparatus for a guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

a gimbaled steering roller having a lateral constraint;

a means for biasing said steering roller in a gimbal direction, wherein said means for biasing said steering roller in the gimbal direction comprises a spring having an end one and an end two mounted between the frame and one end of said steering roller such that said spring end one is mounted to said frame, and said spring end two is mounted to said steering roller, such that said spring applies a rotational force on said steering roller about a gimbal axis; and,

a means for adjusting said bias to achieve desired tracking.

12. The web tracking apparatus of claim 11 wherein said means for adjusting said bias comprises applying a pre-load to said spring to achieve desired tracking.

13. The web tracking apparatus of claim 12 wherein said spring is mounted to said frame by attaching a mounting nut to said spring end one, and threading a screw through the frame, such that said mounting nut is threaded onto said screw to apply the desired pre-load on said spring.

14. The web tracking apparatus of claim 9 wherein said steering roller is mounted on a roller shaft.

15. (once amended) A web tracking apparatus for a guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

a gimbaled steering roller having a lateral constraint wherein said steering roller is mounted on a roller shaft, and wherein said lateral constraint comprises an edge guide which is rotatably mounted on said roller shaft and is axially slidable relative thereto;

a means for biasing said steering roller in a gimbal direction; and,

a means for adjusting said bias to achieve desired tracking.

16. (once amended) The web tracking apparatus of claim 9 further comprising a stop for preventing said steering roller from rotating too far in the gimbal direction.

17. (once amended) A method of web tracking adjustment for guiding a photoconductor loop in a electrostatographic reproduction apparatus on a predetermined path of travel relative to a stationary frame, comprising:

biasing a steering roller in a gimbal direction; and,

adjusting said bias to achieve desired tracking.

18. The method of claim 17 wherein said steering roller has a lateral constraint, and said bias allows the web to ride against said lateral constraint without damaging the web.

19. (once amended) A method of web tracking adjustment for guiding a photoconductor loop in a electrostatographic reproduction apparatus on a predetermined path of travel relative to a stationary frame, comprising:

biasing a steering roller in a gimbal direction wherein said steering roller has a lateral constraint, and said bias allows the web to ride against said lateral constraint without damaging the web, and wherein said steering roller is mounted on a roller shaft, and said lateral constraint comprises an edge guide which is rotatably mounted on said roller shaft and is axially slidable relative thereto; and,

adjusting said bias to achieve desired tracking.

20. (twice amended) A method of web tracking adjustment for guiding a photoconductor loop in a electrostatographic reproduction apparatus on a predetermined path of travel relative to a stationary frame, comprising:

biasing a steering roller in a gimbal direction; and,

adjusting said bias to achieve desired tracking, and further comprising a housing and spring flexures, wherein said housing is pivotally mounted to said frame such that said housing pivots about a gimbal axis, and wherein said steering roller is mounted on a roller shaft, which said shaft is in turn mounted to said housing by said spring flexures, such that said spring flexures allow said steering roller to pivot about a caster axis, while said housing allows said steering roller to pivot about a gimbal axis.

APPENDIX C

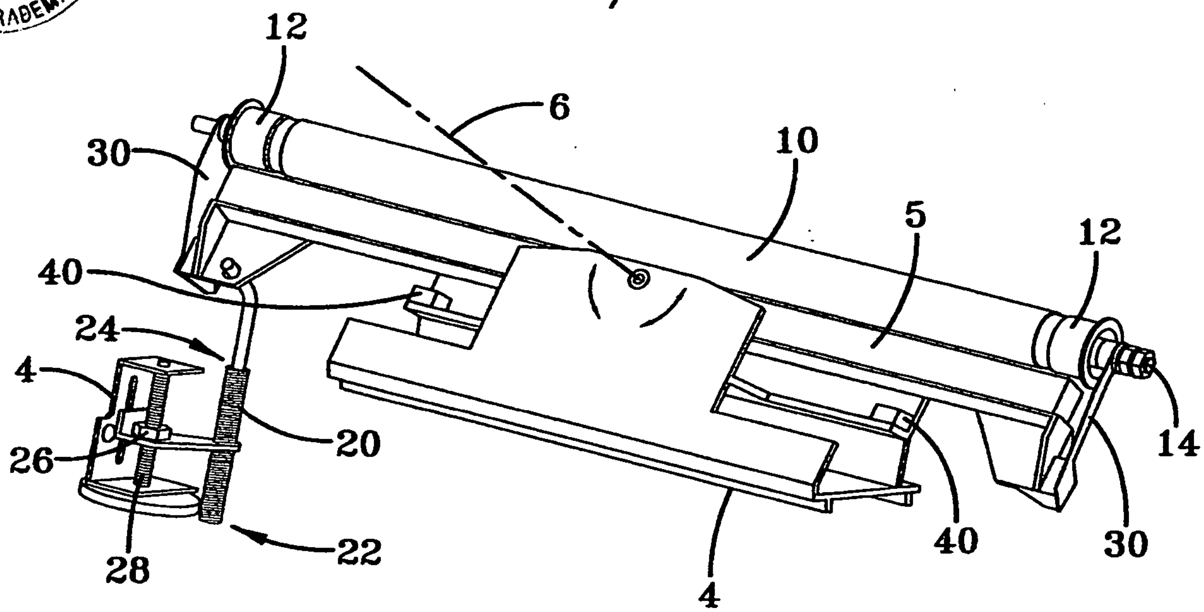

FIG-3

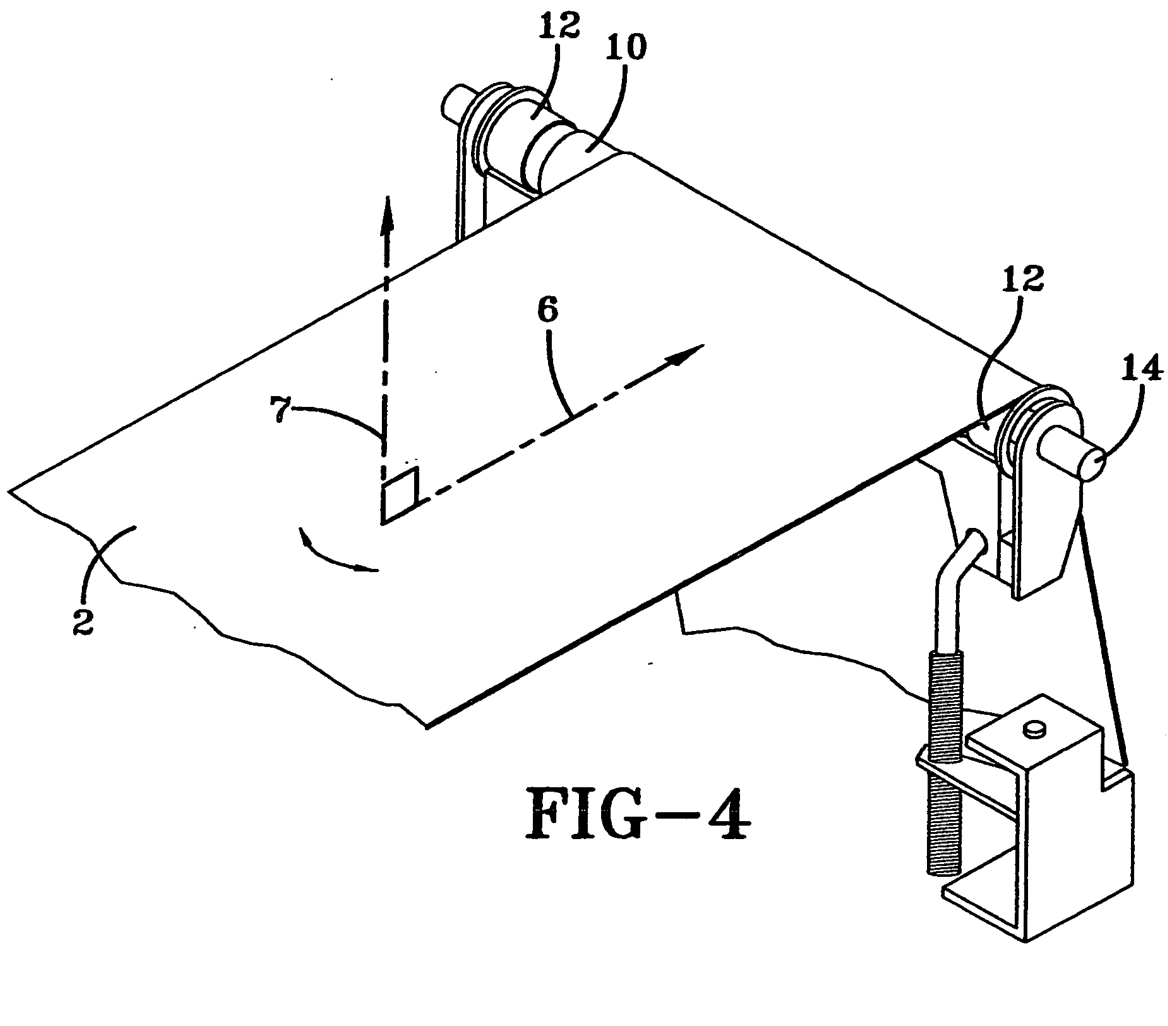

FIG-4

APPENDIX D

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/772,177	01/29/2001	Timothy J. Young	10030	9720

7590 03/18/2003

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EXAMINER	
PHAM, MINH CHAU	

ART UNIT	PAPER NUMBER
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PTO-90C (Rev. 07-01)

Advisory Action	Application No. 09/772,177	Applicant(s) YOUNG ET AL.
	Examiner Minh-Chau Pham	Art Unit 3654

OIPE JC18 JUL 2 1 2003 PATENT & TRADEMARK OFFICE

--The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

THE REPLY FILED 25 February 2003 FAILS TO PLACE THIS APPLICATION IN CONDITION FOR ALLOWANCE. Therefore, further action by the applicant is required to avoid abandonment of this application. A proper reply to a final rejection under 37 CFR 1.113 may only be either: (1) a timely filed amendment which places the application in condition for allowance; (2) a timely filed Notice of Appeal (with appeal fee); or (3) a timely filed Request for Continued Examination (RCE) in compliance with 37 CFR 1.114.

PERIOD FOR REPLY [check either a) or b)]

a) ☒ The period for reply expires 3 months from the mailing date of the final rejection.

b) ☐ The period for reply expires on: (1) the mailing date of this Advisory Action, or (2) the date set forth in the final rejection, whichever is later. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of the final rejection.
ONLY CHECK THIS BOX WHEN THE FIRST REPLY WAS FILED WITHIN TWO MONTHS OF THE FINAL REJECTION. See MPEP 706.07(f).

Extensions of time may be obtained under 37 CFR 1.136(a). The date on which the petition under 37 CFR 1.136(a) and the appropriate extension fee have been filed is the date for purposes of determining the period of extension and the corresponding amount of the fee. The appropriate extension fee under 37 CFR 1.17(a) is calculated from: (1) the expiration date of the shortened statutory period for reply originally set in the final Office action; or (2) as set forth in (b) above, if checked. Any reply received by the Office later than three months after the mailing date of the final rejection, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

1.☐ A Notice of Appeal was filed on _____. Appellant's Brief must be filed within the period set forth in 37 CFR 1.192(a), or any extension thereof (37 CFR 1.191(d)), to avoid dismissal of the appeal.

2.☐ The proposed amendment(s) will not be entered because:

(a) ☐ they raise new issues that would require further consideration and/or search (see NOTE below);

(b) ☐ they raise the issue of new matter (see Note below);

(c) ☐ they are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal; and/or

(d) ☐ they present additional claims without canceling a corresponding number of finally rejected claims.

NOTE: _____.

3.☒ Applicant's reply has overcome the following rejection(s): *claims 3-7, 10-15, 19-20 are now allowable*.

4.☐ Newly proposed or amended claim(s) _____ would be allowable if submitted in a separate, timely filed amendment canceling the non-allowable claim(s).

5.☒ The a)☐ affidavit, b)☐ exhibit, or c)☒ request for reconsideration has been considered but does NOT place the application in condition for allowance because: *See Continuation Sheet*.

6.☐ The affidavit or exhibit will NOT be considered because it is not directed SOLELY to issues which were newly raised by the Examiner in the final rejection.

7.☒ For purposes of Appeal, the proposed amendment(s) a)☐ will not be entered or b)☒ will be entered and an explanation of how the new or amended claims would be rejected is provided below or appended.

The status of the claim(s) is (or will be) as follows:

Claim(s) allowed: *3-7,10-15,19 and 20*.

Claim(s) objected to: _____.

Claim(s) rejected: *1,2,8,9 and 16-18*.

Claim(s) withdrawn from consideration: _____.

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8.☐ The proposed drawing correction filed on _____ is a)☐ approved or b)☐ disapproved by the Examiner.

9.☐ Note the attached Information Disclosure Statement(s)(PTO-1449) Paper No(s). _____.

10.☐ Other: _____

MICHAEL R. MANSEN
PRIMARY EXAMINER

Continuation of 5. does NOT place the application in condition for allowance because: applicants' arguments are not persuasive and do not show how the claims do not read on the prior art.

APPENDIX E

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail, with sufficient postage, in an envelope addressed to: Assistant Commissioner for Patents, Washington D.C. 20231, on

02/25/2003
Date of Deposit

Kathleen K. Bowen
Name of Applicant, Assignee, or Registered Representative

K. K. Bowen
Signature

02/25/2003
Date of Signature

Attorney Docket No. 10030

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

Timothy J. Young, Larry T. Schlitzer, Kevin E. Yousey, Kevin S. Reitter

Serial No. 09/772,177

Filing Date: 01/29/2001

For WEB TRACKING ADJUSTMENT DEVICE AND METHOD THROUGH USE OF A BIASED GIMBAL

Examiner Minh Chau Pham

Group Art Unit No. 3654

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

In response to the office action mailed on November 25, 2002: please amend the application as follows:

Please rewrite claim 3 without prejudice or disclaimer as follows:

3. (once amended) A method of web tracking adjustment for guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

biasing a steering roller in a gimbal direction wherein said bias allows the web to ride against a lateral constraint without damaging the web, and wherein said steering roller is mounted on a roller shaft, and said lateral constraint comprises an edge guide which is rotatably mounted on said roller shaft and is axially slidable relative thereto; and,

adjusting said bias to achieve desired tracking.

Please rewrite claim 4 without prejudice or disclaimer as follows:

4. (once amended) A method of web tracking adjustment for guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

biasing a steering roller in a gimbal direction wherein said bias allows the web to ride against a lateral constraint without damaging the web, wherein said steering roller is biased by a spring having an end one and an end two mounted between the frame and one end of said steering roller such that said spring end one is mounted to said frame, and said spring end two is mounted to said steering roller, such that said spring applies a rotational force on said steering roller about a gimbal axis; and,

adjusting said bias to achieve desired tracking.

Please rewrite claim 7 without prejudice or disclaimer as follows:

7. (twice amended) A method of web tracking adjustment for guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

biasing a steering roller in a gimbal direction;

adjusting said bias to achieve desired tracking, and further comprising a housing and spring flexures, wherein said housing is pivotally mounted to said

frame such that said housing pivots about a gimbal axis, and wherein said steering roller is mounted on a roller shaft, which said shaft is in turn mounted to said housing by said spring flexures, such that said spring flexures allow said steering roller to pivot about a caster axis, while said housing allows said steering roller to pivot about a gimbal axis.

Please rewrite claim 10 without prejudice or disclaimer as follows:

10. (twice amended) A web tracking apparatus for a guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

a gimbaled steering roller having a lateral constraint;

a means for biasing said steering roller in a gimbal direction; and,

a means for adjusting said bias to achieve desired tracking, and further comprising a housing and spring flexures, wherein said housing is pivotally mounted to said frame such that said housing pivots about a gimbal axis of said steering roller, and wherein said steering roller is mounted on a roller shaft, which said shaft is in turn mounted to said housing by said spring flexures, such that said spring flexures allow said steering roller to pivot about a caster axis, while said housing allows said steering roller to pivot about a gimbal axis.

Please rewrite claim 11 without prejudice or disclaimer as follows:

11. (once amended) A web tracking apparatus for a guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

a gimbaled steering roller having a lateral constraint;

a means for biasing said steering roller in a gimbal direction, wherein said means for biasing said steering roller in the gimbal direction comprises a spring having an end one and an end two mounted between the frame and one end of said steering roller such that said spring end one is mounted to said frame, and said spring end two is mounted to said steering roller, such that said spring applies a rotational force on said steering roller about a gimbal axis; and,

a means for adjusting said bias to achieve desired tracking.

Please rewrite claim 15 without prejudice or disclaimer as follows:

15. (once amended) A web tracking apparatus for a guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

a gimbaled steering roller having a lateral constraint wherein said steering roller is mounted on a roller shaft, and wherein said lateral constraint comprises an edge guide which is rotatably mounted on said roller shaft and is axially slidable relative thereto;

a means for biasing said steering roller in a gimbal direction; and,

a means for adjusting said bias to achieve desired tracking.

Please rewrite claim 19 without prejudice or disclaimer as follows:

19. (once amended) A method of web tracking adjustment for guiding a photoconductor loop in a electrostatographic reproduction apparatus on a predetermined path of travel relative to a stationary frame, comprising:

biasing a steering roller in a gimbal direction wherein said steering roller has a lateral constraint, and said bias allows the web to ride against said lateral constraint without damaging the web, and wherein said steering roller is mounted on a roller shaft, and said lateral constraint comprises an edge guide which is rotatably mounted on said roller shaft and is axially slidable relative thereto; and,

adjusting said bias to achieve desired tracking.

Please rewrite claim 20 without prejudice or disclaimer as follows:

20. (twice amended) A method of web tracking adjustment for guiding a photoconductor loop in a electrostatographic reproduction apparatus on a predetermined path of travel relative to a stationary frame, comprising:

biasing a steering roller in a gimbal direction; and,

adjusting said bias to achieve desired tracking, and further comprising a housing and spring flexures, wherein said housing is pivotally mounted to said frame such that said housing pivots about a gimbal axis, and wherein said steering roller is mounted on a roller shaft, which said shaft is in turn mounted to said housing by said spring flexures, such that said spring flexures allow said

steering roller to pivot about a caster axis, while said housing allows said steering roller to pivot about a gimbal axis.

REMARKS

Claims 1-2, 9,14, and 16-18 stand rejected under 35 U.S.C. 102 (b) as being anticipated by Moe et al. Claims 1 and 8 stand rejected under 35 U.S.C. 102 (b) as being anticipated by Morse. (3,913,813). Claims 1 and 8 stand rejected under 35 U.S.C. 102(b) as being anticipated by Morse et al (3,608,796). Applicants respectfully submit that for the following reasons, claims 1-2, 9,14, and 16-18 are not anticipated under 35 U.S.C. 102(b) by Moe et al, and claims 1 and 8 are not anticipated under 35 U.S.C. 102(b) by Morse (3,913,813) or by Morse et al (3,608,796). Claims 3-7, 10-13, 15, and 19-20 would be allowable if rewritten to overcome the rejections under 35 USC 112, second paragraph, set forth in this office action (there were none set for the in this office action), and to include all of the limitations of the base claim and any intervening claims. Applicants respectfully request allowance of amended claims 3-7, 10-13, 15, and 19-20 and reconsideration and further examination of claims 1-2, 9,14, and 16-18.

Drawings

The proposed drawing correction filed on September 22, 2002 has been approved by the Examiner. The formal amended drawing is attached to this correspondence. Applicants respectfully request the Examiner enter said formal drawing.

Art Rejections

Moe et al (U.S. 5,659,851)

Claims 1-2, 9,14, and 16-18 stand rejected under 35 U.S.C. 102 (b) as being anticipated by Moe et al. With respect to claims 1, 2, 17, and 18, applicants respectfully requested the Examiner identify where Moe et al discloses "A method of web tracking adjustment for guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising: biasing a steering roller in a gimbal direction; and, adjusting said bias to achieve desired tracking" (applicant's claim 1) so applicants could adequately respond. The Examiner responded by stating that "Moe et al (US 5,659,851) discloses biasing the steering roller (14) in the gimbal direction (56) through the use of springs (80). " The axis (56) of Moe et al. is not the gimbal direction. Moe et al. calls it the "steering axis 56", which corresponds to the "gimbal axis" of the captioned application. Applicants respectfully submit that the Examiner's construction of Moe et al. is in error.

Examiner further states that Moe et al discloses "a means for adjusting (94)(96)", but applicant's claim requires "adjusting said bias to achieve desired tracking." Examiner has not shown that (94) and (96) adjust the bias to achieve desired tracking. Moe et al. describes item (94) as "a tension adjusting disc (94)" and item (96) as a "tension releasing cam (96)" [column 8, lines 28-29]. "A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described in a single prior art reference" [MPEP 2131 quoting *Verdegaal Bros. v. Union Oil Co. of California,* 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). Applicants again respectfully request Examiner state where in Moe et al it discloses biasing the steering roller in the gimbal direction, as previously defined, and adjusting said bias to achieve desired tracking, so that applicants can adequately respond. In the absence of such, applicants respectfully submit that the Examiner has not met his burden

under 102(b), and rejection of claims 1, 2,17, and 18 on this basis is in error, and request that the rejection on this basis be withdrawn.

With regard to claims 9, 14 and 16, applicants respectfully requested that Examiner identify where Moe et al discloses "a gimbaled steering roller having a lateral constraint; a means for biasing said steering roller in a gimbal direction; and, a means for adjusting said bias to achieve desired tracking" so applicants could adequately respond. Examiner responded by stating that Moe et al disclosed a "means for biasing (80) in a gimbal direction (56); a means for adjusting (94)(96)." However, as stated above, the axis (56) of Moe et al. is not the gimbal direction. Moe et al. calls it the "steering axis 56", which corresponds to the "gimbal axis" of the captioned application.

Further, items (94) and (96) are not "means for adjusting said bias to achieve desired tracking." Moe et al. Describes item (94) as "a tension adjusting disc (94)" and item (96) as a "tension releasing cam (96)" [column 8, lines 28-29]. "A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described in a single prior art reference" [MPEP 2131 quoting *Verdegaal Bros. v. Union Oil Co. of California,* 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). Applicants again respectfully request the Examiner show where Moe et al discloses a "means for biasing said steering roller in a gimbal direction", and "a means for adjusting said bias to achieve desired tracking." In the absence of such, applicants respectfully submit that the Examiner has not met his burden under 102(b), and rejection of claims 9, 14 and 16 on this basis is in error, and request that the rejection on this basis be withdrawn.

Morse (US 3,913,813)

Claims 1 and 8 stand rejected under 35 U.S.C. 102 (b) as being anticipated by Morse. (3,913,813). Examiner states that Morse discloses "biasing the steering roller (11) in the gimbal direction (20) through the use of resilient wire (61)." The axis (20) of Morse is not the gimbal direction. Morse

refers to (20) as a "gimbal axis." Applicants respectfully submit that the Examiner's construction of Morse (3,913,813) is in error.

The Examiner furthers states that Morse (3,913,813) discloses "adjusting the bias (60)(70)(72)". However, the yoke/screw assembly (70)(72) in Morse results in a force about the caster axis (30), not the gimbal axis (20) (see Figures 2a and 2b). Nowhere in Morse does it disclose "biasing a steering roller in a gimbal direction; and, adjusting said bias to achieve desired tracking". "A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described in a single prior art reference" [MPEP 2131 quoting *Verdegaal Bros. v. Union Oil Co. of California,* 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). Applicants again respectfully request Examiner state where in Morse (3,913,813) it discloses biasing the steering roller in the gimbal direction, and adjusting said bias to achieve desired tracking, so that applicants can adequately respond. In the absence of such, applicants respectfully submit that the Examiner has not met his burden under 102(b), and rejection of claims 1 and 8 on this basis is in error, and request that the rejection on this basis be withdrawn.

Morse et al (US 3,608796)

Claims 1 and 8 stand rejected under 35 U.S.C. 102(b) as being anticipated by Morse et al (3,608,796). Examiner states that Morse et al discloses "biasing the steering roller (2) in the gimbal direction (34) through the use of flexure arm (40) and the U-shaped spring bracket 52." The axis (34) of Morse et al is not the gimbal direction. Morse et al refers to (34) as a "gimbal axis." Further, flexure arm (40) is used to "adjustably position the roller about axis **32**" (column 2, lines 68-69), which is the caster axis. The U-shaped bracket (52) "exerts a force on flexure **40** in the direction of arrow **54**" (column 3 lines 11-12). A force in the direction (54) would cause movement about the caster axis (32), not the gimbal axis (34) (see Figure 1). Applicants respectfully submit that the Examiner's construction of Morse et al (3,608,796) is in error.

Examiner further states Morse et al discloses "adjusting the bias (36)(44)(46)." The adjustment features Examiner refers to (36)(44)(46) are to position the roller (2) about the adjustment axis (32) (see column 2 lines 59-70), not the gimbal axis. "A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described in a single prior art reference" [MPEP 2131 quoting *Verdegaal Bros. v. Union Oil Co. of California,* 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). Applicants again respectfully request Examiner state where in Morse et al (3,608,796) it discloses biasing the steering roller in the gimbal direction, and adjusting said bias to achieve desired tracking, so that applicants can adequately respond. In the absence of such, applicants respectfully submit that the Examiner has not met his burden under 102(b), and rejection of claims 1 and 8 on this basis is in error, and request that the rejection on this basis be withdrawn.

Applicants respectfully submit that claims 1-20 are allowable as herein amended, and request that the amendment to the drawings and the claims be entered, and the rejections against them be withdrawn.

Respectfully submitted,

Kath K Bowen

Kathleen K. Bowen, Esq.
Registration No. 42,352
Attorney for Applicant

APPENDIX F

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/772,177	01/29/2001	Timothy J. Young	10030	9720

7590 11/25/2002

Kathleen K. Bowen
311 Hillbrook Dr.
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EXAMINER	
PHAM, MINH CHAU	
ART UNIT	**PAPER NUMBER**
3654	

DATE MAILED: 11/25/2002

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 07-01)

Office Action Summary	Application No.	Applicant(s)
	09/772,177	YOUNG ET AL.
	Examiner	Art Unit
	Minh-Chau Pham	3654

OIPE JUL 2 1 2003 PATENT & TRADEMARK OFFICE

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 22 September 2002.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-20 is/are pending in the application.

4a) Of the above claim(s) ____ is/are withdrawn from consideration.

5)☐ Claim(s) ____ is/are allowed.

6)☒ Claim(s) 1-20 is/are rejected.

7)☐ Claim(s) ____ is/are objected to.

8)☐ Claim(s) ____ are subject to restriction and/or election requirement.

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Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on ____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☒ The proposed drawing correction filed on 22 September 2002 is: a)☒ approved b)☐ disapproved by the Examiner

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. ____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) ____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). ____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Drawings

1. The proposed drawing correction and/or the proposed substitute sheets of drawings, filed on September 22, 2002 have been approved. A proper drawing correction or corrected drawings are required in reply to the Office action to avoid abandonment of the application.

Claim Rejections - 35 USC § 102

2. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

3. Claims 1-2, 9, 14, and 16-18 are rejected under 35 U.S.C. 102(b) as being anticipated by Moe et al. (US 5,659,851).

Moe et al. disclose applicants' claimed invention, specifically teaching a web tracking apparatus (10) and a method of web tracking adjustment, for guiding a moving web/photoconductor loop (12) in a predetermined path of travel relative to a stationary frame (84)(col. 7, lines 6-8), comprising:

a gimbaled steering roller (14) having a lateral constraint (61A)(62A);

a means for biasing (80) in a gimbal direction (56);

a means for adjusting (94)(96);

a roller shaft (59); and

a stop (88)(col. 9, lines 2-4).

4. Claims 1 and 8 are rejected under 35 U.S.C. 102(b) as being anticipated by Morse (US 3,913,813: ref. 4 in form PTO-1449).

Morse discloses applicants' claimed invention, specifically teaching a method of web tracking adjustment, for guiding a moving web (15) in a predetermined path of travel relative to a stationary frame (53), comprising:

biasing (61) a steering roller (11) in a gimbal direction (20);

adjusting the bias (60)(70)(72);

mounting the steering roller to the stationary frame (53)(col. 6, lines 1-3); and

pivoting the steering roller about a caster axis (30)(col. 6, lines 15-20).

5. Claims 1 and 8 are rejected under 35 U.S.C. 102(b) as being anticipated by Morse et al. (US 3,608,796).

Morse et al. disclose applicants' claimed invention, specifically teaching a method of web tracking adjustment, for guiding a moving web (16) in a predetermined path of travel relative to a stationary frame (14), comprising:

biasing (40)(52) a steering roller (2) in a gimbal direction (34);

adjusting the bias (36)(44)(46);

mounting the steering roller to the stationary frame [see Fig. 1, where (12) mounts (2) to (14)]; and

pivoting the steering roller about a caster axis (32).

Allowable Subject Matter

6. Claims 3-7, 10-13, 15, and 19-20 would be allowable if rewritten to overcome the rejection(s) under 35 U.S.C. 112, second paragraph, set forth in this Office action and to include all of the limitations of the base claim and any intervening claims.

7. The following is a statement of reasons for the indication of allowable subject matter: the prior art of record, taken as a whole, fails to disclose or render obvious a method of web tracking adjustment or a web tracking apparatus comprising all the limitations claimed, including an edge guide that is axially slidable as recited in claims 3, 15, and 19, an end two of the spring that is mounted to one end of the steering roller such that the spring applies a rotational force as recited in claims 4 and 11, and a shaft that is mounted to the housing by spring flexures as recited in claims 7, 10, and 20.

Response to Arguments

8. Applicants' arguments filed September 22, 2002 have been fully considered but they are not persuasive. Moe et al. (US 5,659,851) discloses biasing the steering roller (14) in the gimbal direction (56) through the use of springs (80). Morse (US 3,913,813) discloses biasing the steering roller (11) in the gimbal direction (20) through the use of the resilient wire (61). Morse et al. (US 3,608,796) discloses biasing the steering roller (2) in the gimbal direction (34) through the use of the flexure arm (40) and the U-shaped spring bracket (52). Moe et al., Morse, and Morse et al., all teach the pivoting of the steering roller about the gimbal axis.

Conclusion

9. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Minh-Chau Pham whose telephone number is (703) 305-0766. The examiner can normally be reached on Monday-Thursday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Katherine Matecki can be reached on (703) 308-2688. The fax phone numbers for the organization where this application or proceeding is assigned are (703) 872-9326 for regular communications and (703) 872-9327 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-1113.

pmc
November 21, 2002

KATHY MATECKI
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 3600

APPENDIX G

Docket No.10030

APPLICATION FOR UNITED STATES PATENT

WEB TRACKING ADJUSTMENT DEVICE AND METHOD THROUGH USE OF A BIASED GIMBAL

INVENTORS: Timothy J. Young
Larry T. Schlitzer
Kevin S. Reitter
Kevin E. Yousey

DATE : January 29, 2001

WEB TRACKING ADJUSTMENT DEVICE AND METHOD THROUGH USE OF A BIASED GIMBAL

BACKGROUND

The present invention is in the field of mechanisms for tracking moving webs. More specifically this invention relates to the tracking method of the film on the film handling system, and a means for adjusting the film tracking, in electrophotographic printers and copiers.

In high speed electrostatographic reproduction apparatus, it is a common practice to employ an elongated photoconductive belt or web adapted to record transferable images while the web is moving in a path in operative relation with various process stations. Typically the web is supported by, and driven about, at least one roller. With a roller support, there is a tendency for the moving web to shift laterally, or cross-track, with respect to such a roller. This tendency can be due to manufacturing tolerances, such as the inability to manufacture perfectly cylindrical rollers, or to exactly mount the rollers in a web supporting system. Various apparatus for correcting such lateral shifting of roller-supported webs are known, such as crowned rollers, flanged rollers, servo-actuated steering rollers, or self-actuating steering rollers. Crowned rollers generally are not suitable for use with a web in an electrostatographic reproduction apparatus, because they force the web toward the apex of such rollers, cause distortion of the web, and produce local stresses in the web at the crown which can damage the web. Flanged rollers generally are also not suitable because they produce a concentrated loading at the edges of the web, resulting in edge buckling, seam splitting, or excessive edge wear.

Electrostatographic reproduction apparatus therefore typically utilize servo-actuated or self-actuated steering rollers. While such steering rollers generally correct in a gross manner the cross-track shifting of the web, they tend to produce significant lateral movement of the web at an uneven rate as it is re-aligned. This can adversely effect the resulting image quality.

Another method for web tracking is disclosed in U.S. Pat. No. 4,901,903 by Blanding, which describes a steering roller mounted on a pivoted yoke, wherein the roller has an edge guide, and an edge guide adjustment mechanism. In this method, a light tension spring applies a force to the yoke to rotate the roller about a caster axis to impede aberrant lateral movement, and provide corrective action should it occur. This method, though useful, takes a fair amount of very limited space. It is also difficult to make fine adjustments to the tracking using the apparatus disclosed in Blanding.

A method and apparatus for web tracking, and web tracking adjustment is desired which is simple, cost effective, can more effectively use the limited space, and which can make fine adjustments.

SUMMARY OF THE INVENTION

A method and apparatus for web tracking adjustment for a web handling system is disclosed, comprising biasing a steering roller in a gimbal direction, and adjusting the bias to achieve the desired tracking.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a side view of a web/roller system according to an aspect of the invention.

FIGURE 2 is a top view of a continuous web/roller system according to an aspect of the invention.

FIGURE 3 is an isometric view of a steering roller and biasing apparatus according to an aspect of the invention.

FIGURE 4 is an isometric view of a steering roller and biasing apparatus, with a moving web according to an aspect of the invention.

DETAILED DESCRIPTION

The method and apparatus of the preferred embodiment will be described in accordance with an electrostatographic recording medium. The invention, however, is not limited to methods and apparatus for tracking such a medium, as tracking, and adjustment of the tracking for any web/roller system is within the spirit of the invention.

Various aspects of the invention are presented in Figures 1-4 which are not drawn to scale and in which like components are numbered alike. Referring now to these Figures, in a closed loop web/roller system **8**, at least one steering roller **10** is provided, that is the roller which is free to move in some fashion so as to "steer" the web laterally (parallel to the steering roller **10** longitudinal axis **9**) to bring it to the desired position. One way in which a roller may move is by "gimballing" the roller, i.e. by mounting the roller for pivotal movement about a gimbal axis **6** which is parallel to the direction of linear movement of the entering web, and which preferrably intersects the longitudinal axis **9** of the roller at the midpoint of the roller. Due to functional constraints, the steering roller **10** may not be able to pivot exactly about an axis which intersects the longitudinal axis **9** of the steering roller **10** at the midpoint of the steering roller **10**, if this is the case then an axis which is parallel to the direction of linear movement of the entering web **2**, and comes close to intersecting the steering roller at the midpoint of its longitudinal axis **9** will suffice for the gimbal axis **6**. Another way in which a roller may move is by mounting the roller for pivotal movement about a caster axis **7**, which is an axis perpendicular to the gimbal axis, which intersects the gimbal axis **6** upstream of the roller. A roller may be both "castered" and "gimbaled", which means that such a roller is able to pivot about both the caster axis **7** and the gimbal axis **6**. In the drawings a four roller closed loop system **8** is shown. Besides the steering roller **10** there is also a registration roller **43** and a drive roller **41** which do not steer, and a tension roller **42** which moves in the caster and gimbal direction, and thus allows for some correction of the direction of the

web **2**. This is just an example of one type of system for which the invention is useful, and does not in any way limit the invention to such a system.

According to an aspect of the invention, a method of web tracking adjustment for guiding a moving web **2** in a predetermined path of travel relative to a stationary frame **4** comprises biasing a steering roller **10** in a gimbal direction, and adjusting the bias to achieve desired tracking. By biasing the steering roller **10** in a gimbal direction it is meant that the steering roller is pivoted about the gimbal axis **6** such that the web **2** on the downstream side of the steering roller **10** is not perpendicular to the longitudinal axis **9** of the steering roller **10**. This can be seen in Figure 2, which is a top view of the web/roller system **8**, layed out flat for viewing purposes.

According to a further embodiment of this invention, the steering roller **10** has a lateral constraint **12**, and the bias allows the web **2** to ride against the lateral constraint **12** without damaging the web **2**. In a preferred embodiment, the steering roller **10** is mounted on a roller shaft **14**, and the lateral constraint **12** comprises an edge guide which is rotatably mounted on the roller shaft **14** and is axially slidable relative thereto.

In a further preferred embodiment, the steering roller **10** is biased by a spring **20** having an end one **22** and an end two **24** mounted between the frame **4** and one end of the steering roller **10** such that the spring end one **22** is mounted to the frame **4**, and the spring end two **24** is mounted to the steering roller **10**, such that the spring **20** applies a rotational force on the steering roller **10** about a gimbal axis **6**. This is just one means of biasing the steering roller in the gimbal direction, any suitable means is within the purview of this invention.

According to an aspect of the invention, a means for adjustment is accomplished by applying a pre-load to the spring **20** to achieve the desired tracking. One method for applying this pre-load is by attaching a mounting nut **26** to the spring end one **22**, and threading a mounting screw **28** through the frame **4**, such that the mounting nut **26** is threaded onto the mounting screw **28** to apply the desired pre-load on said spring. There are many ways to apply pre-loading on a spring, and many means for adjusting the pre-load on a spring other

than the method disclosed, all such suitable methods are within the purview of this invention.

According to a further preferred embodiment of the invention, the web tracking apparatus further comprises a housing **5** and spring flexures **30**. The housing **5** is pivotally mounted to the frame **4** such that the housing **5** pivots about the gimbal axis **6**. The steering roller **10** is mounted on a roller shaft **14**, which roller shaft **14** is in turn mounted to the housing **5** by the spring flexures **30**, such that the spring flexures **30** allow the steering roller **10** to pivot about the caster axis **7**, while the housing **5** allows the steering roller **10** to pivot about the gimbal axis **6**.

This invention is a useful means of controlling and adjusting the tracking on a web/roller system. This invention is also useful however, when used in conjunction with a self-adjusting method of control, such as the feedback control described in U.S. Patent No. 4,961,089, by Jamzadeh, which patent is hereby incorporated by reference.

We Claim:

1. A method of web tracking adjustment for guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

biasing a steering roller in a gimbal direction; and,

adjusting said bias to achieve desired tracking.

2. The method of claim 1 wherein said steering roller has a lateral constraint, and said bias allows the web to ride against said lateral constraint without damaging the web.

3. The method of claim 2 wherein said steering roller is mounted on a roller shaft, and said lateral constraint comprises an edge guide which is rotatably mounted on said roller shaft and is axially slidable relative thereto.

4. The method of claim 2 wherein said steering roller is biased by a spring having an end one and an end two mounted between the frame and one end of said steering roller such that said spring end one is mounted to said frame, and said spring end two is mounted to said steering roller, such that said spring applies a rotational force on said steering roller about a gimbal axis.

5. The method of claim 4 wherein said adjustment comprises applying a pre-load to said spring to achieve desired tracking.

6. The method of claim 5 wherein said spring is mounted to said frame by attaching a mounting nut to said spring end one, and threading a screw through the frame, such that said mounting nut is threaded onto said screw to apply the desired pre-load on said spring.

7. The method of claim 1 further comprising a housing and spring flexures, wherein said housing is pivotally mounted to said frame such that said housing pivots about a gimbal axis, and wherein said steering roller is mounted on a roller shaft, which said shaft is in turn mounted to said housing by said spring flexures, such that said spring flexures allow said steering roller to pivot about a caster axis, while said housing allows said steering roller to pivot about a gimbal axis.

8. The method of claim 1 wherein said steering roller is mounted to said stationary frame in such a manner as to allow said steering roller to pivot about a caster axis.

9. A web tracking apparatus for a guiding a moving web in a predetermined path of travel relative to a stationary frame, comprising:

a gimbaled steering roller having a lateral constraint;

a means for biasing said steering roller in a gimbal direction; and,

a means for adjusting said bias to achieve desired tracking

10. The apparatus of claim 9 further comprising a housing and spring flexures, wherein said housing is pivotally mounted to said frame such that said housing pivots about a gimbal axis of said steering roller, and wherein said steering roller is mounted on a roller shaft, which said shaft is in turn mounted to said housing by said spring flexures, such that said spring flexures allow said steering roller to pivot about a caster axis, while said housing allows said steering roller to pivot about a gimbal axis.

11. The web tracking apparatus of claim 9 wherein said means for biasing said steering roller in the gimbal direction comprises a spring having an end one and an end two mounted between the frame and one end of said steering roller such that said spring end one is mounted to said frame, and said spring end two is mounted to said steering roller, such that said spring applies a rotational force on said steering roller about a gimbal axis.

12. The web tracking apparatus of claim 11 wherein said means for adjusting said bias comprises applying a pre-load to said spring to achieve desired tracking.

13. The web tracking apparatus of claim 12 wherein said spring is mounted to said frame by attaching a mounting nut to said spring end one, and threading a screw through the frame, such that said mounting nut is threaded onto said screw to apply the desired pre-load on said spring.

14. The web tracking apparatus of claim 9 wherein said steering roller is mounted on a roller shaft.

15. The web tracking apparatus of claim 14 wherein said lateral constraint comprises an edge guide which is rotatably mounted on said roller shaft and is axially slidable relative thereto.

16. The web tracking apparatus of claim 9 further comprising a stopping means for preventing said steering roller from rotating too far in the gimbal direction.

17. A method of web tracking adjustment for guiding a photoconducter loop in a electrostatographic reproduction apparatus on a predetermined path of travel relative to a stationary frame, comprising:

biasing a steering roller in a gimbal direction; and,

adjusting said bias to achieve desired tracking.

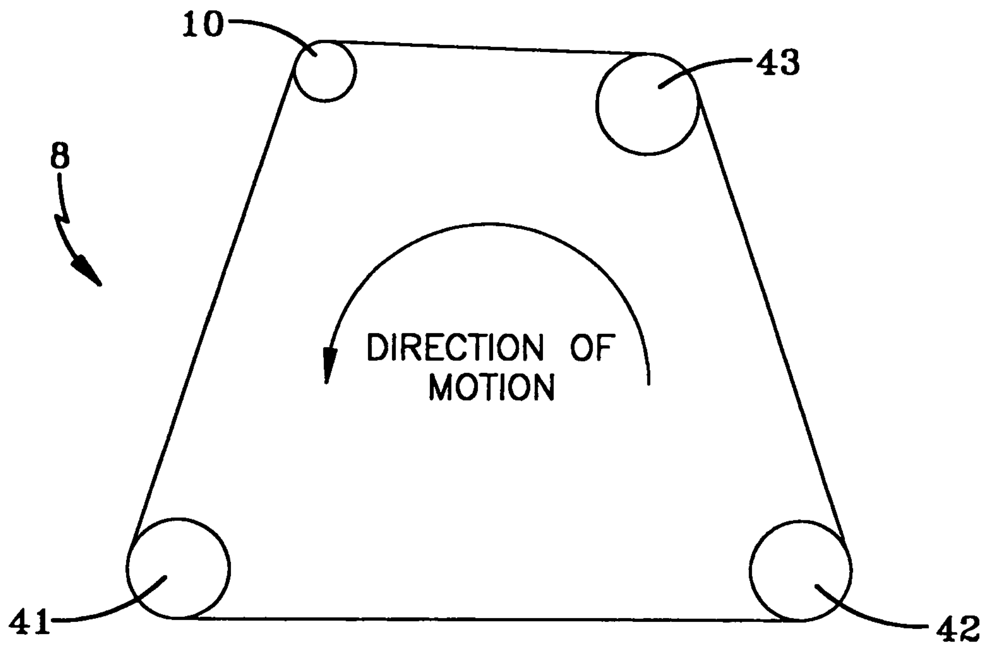
18. The method of claim 17 wherein said steering roller has a lateral constraint, and said bias allows the web to ride against said lateral constraint without damaging the web.

19. The method of claim 18 wherein said steering roller is mounted on a roller shaft, and said lateral constraint comprises an edge guide which is rotatably mounted on said roller shaft and is axially slidable relative thereto.

20. The method of claim 17 further comprising a housing and spring flexures, wherein said housing is pivotally mounted to said frame such that said housing pivots about a gimbal axis, and wherein said steering roller is mounted on a roller shaft, which said shaft is in turn mounted to said housing by said spring flexures, such that said spring flexures allow said steering roller to pivot about a caster axis, while said housing allows said steering roller to pivot about a gimbal axis.

ABSTRACT

A method and apparatus for web tracking adjustment for a web handling system is disclosed, comprising biasing a steering roller in a gimbal direction, and adjusting the bias to achieve the desired tracking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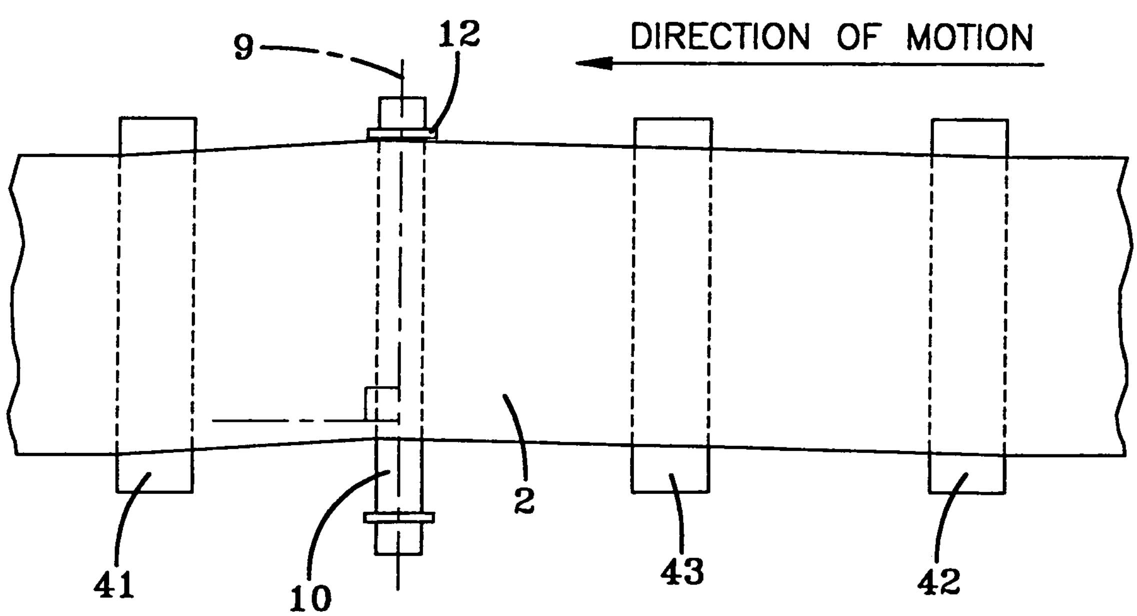
8
DIRECTION OF MOTION
41
42

FIG-1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DIRECTION OF MOTION
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FIG-2

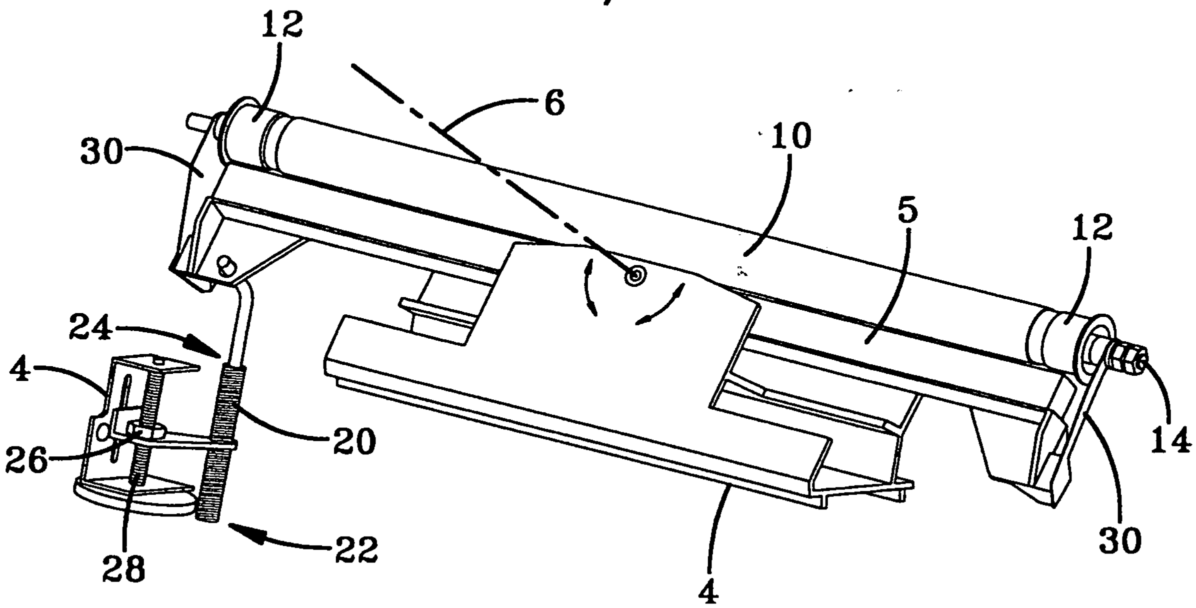

FIG-3

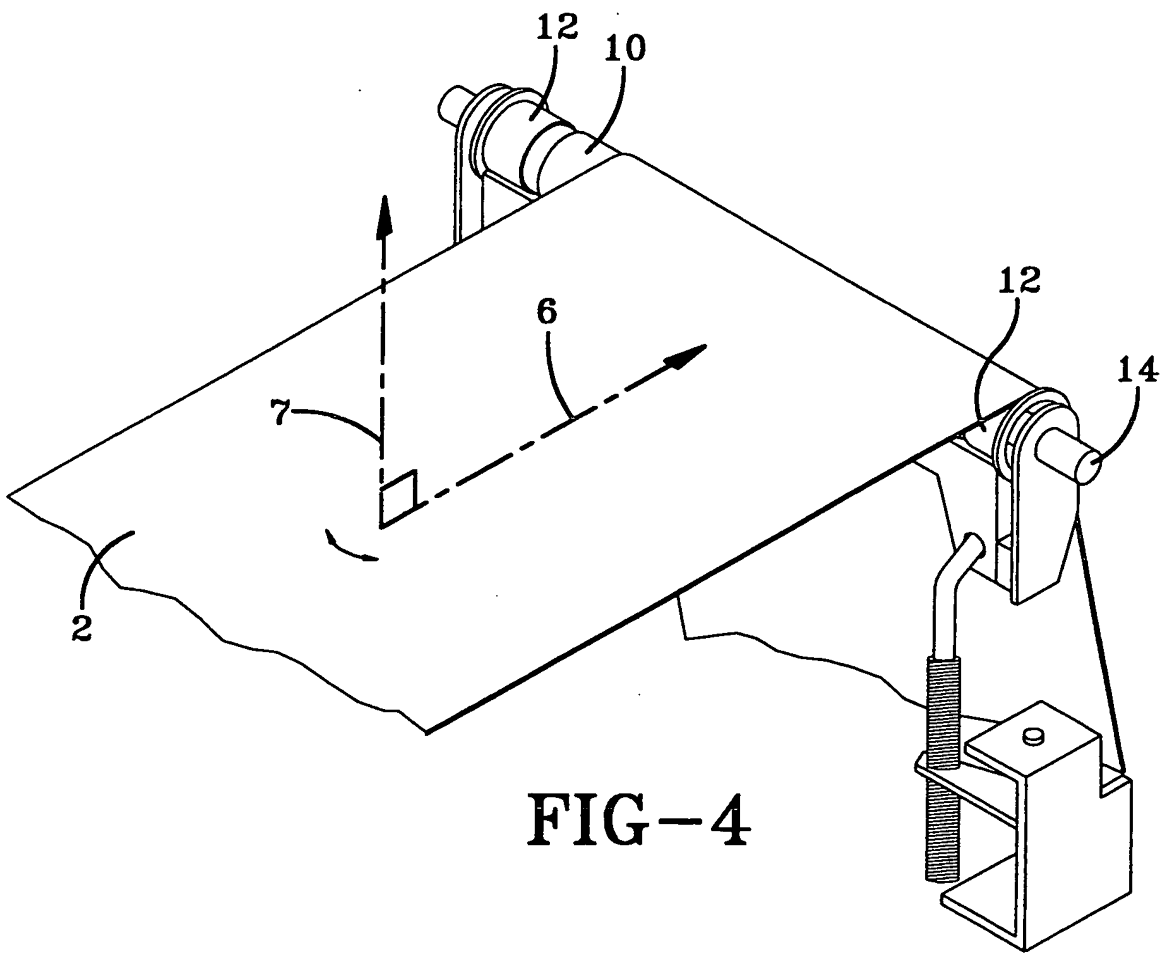

FIG-4

APPENDIX H

US005659851A

United States Patent [19]

Moe et al.

[11] **Patent Number:** 5,659,851

[45] **Date of Patent:** Aug. 19, 1997

[54] **APPARATUS AND METHOD FOR STEERING AN ENDLESS BELT**

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[73] Assignee: **Minnesota Mining and Manufacturing Company**, St. Paul, Minn.

[21] Appl. No.: **558,247**

[22] Filed: **Nov. 17, 1995**

[51] Int. $Cl.^6$ G03G 15/00

[52] U.S. Cl. 399/165; 226/15; 226/170; 226/174; 226/180

[58] Field of Search 355/212; 198/806, 198/808, 810.01, 810.04; 226/15, 18, 170, 174, 180, 190; 474/122, 123, 124; 399/165

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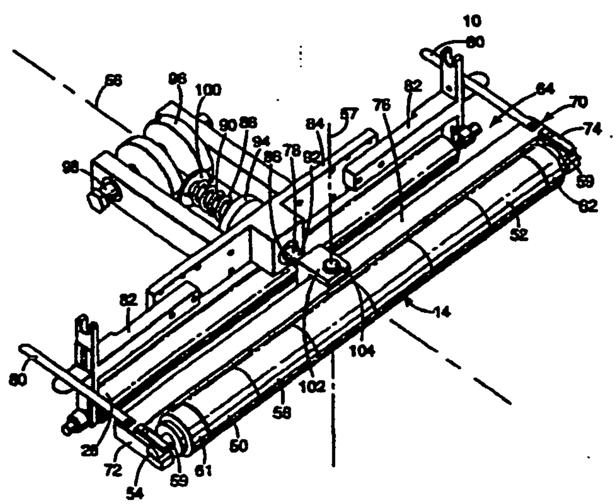
Primary Examiner—R. L. Moses
Attorney, Agent, or Firm—William K. Weimer

[57] **ABSTRACT**

An apparatus useful for passively steering an endless belt toward a lateral target belt position while the endless belt is transported by a transporting mechanism. A steering roller contacts the belt inner surface, the steering roller being rotatable about a roller axis and being pivotable about a steering axis, and the steering roller having a first roller end. A carriage supports the steering roller and is pivotable about a steering axis such that the steering roller is pivotable about the steering axis. A first member is positioned adjacent to the first roller end and functionally connected to the carriage. The first member contacts the belt inner surface when the first belt edge extends sufficiently beyond the first roller end. The first member applies greater friction to the endless belt than the steering roller when the belt contacts the first member. The first member is positioned relative to the steering axis such that contact between the first member and the belt causes the first member to apply a first torque to the carriage means about the steering axis.

22 Claims, 4 Drawing Sheets



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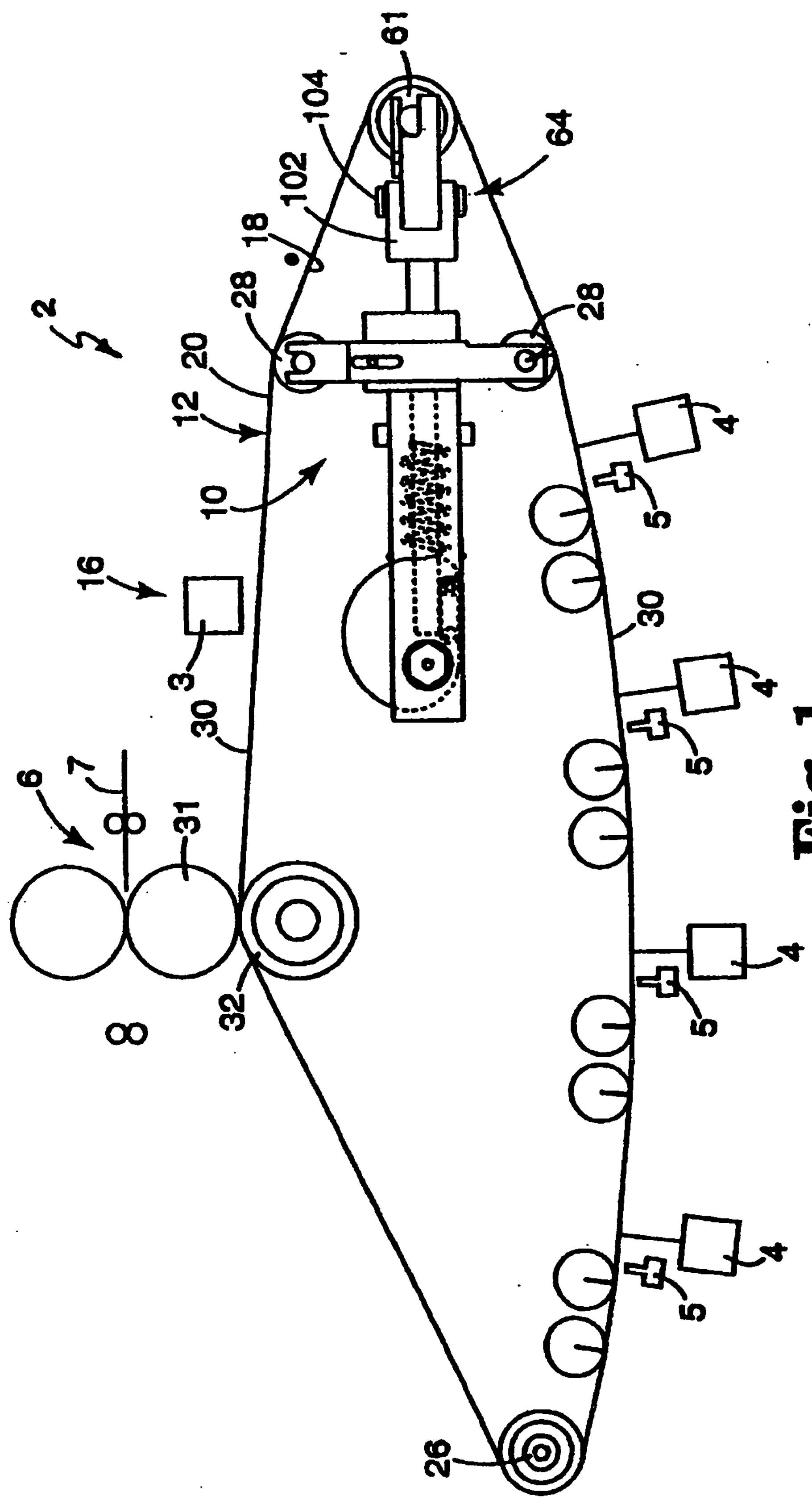

Fig. 1

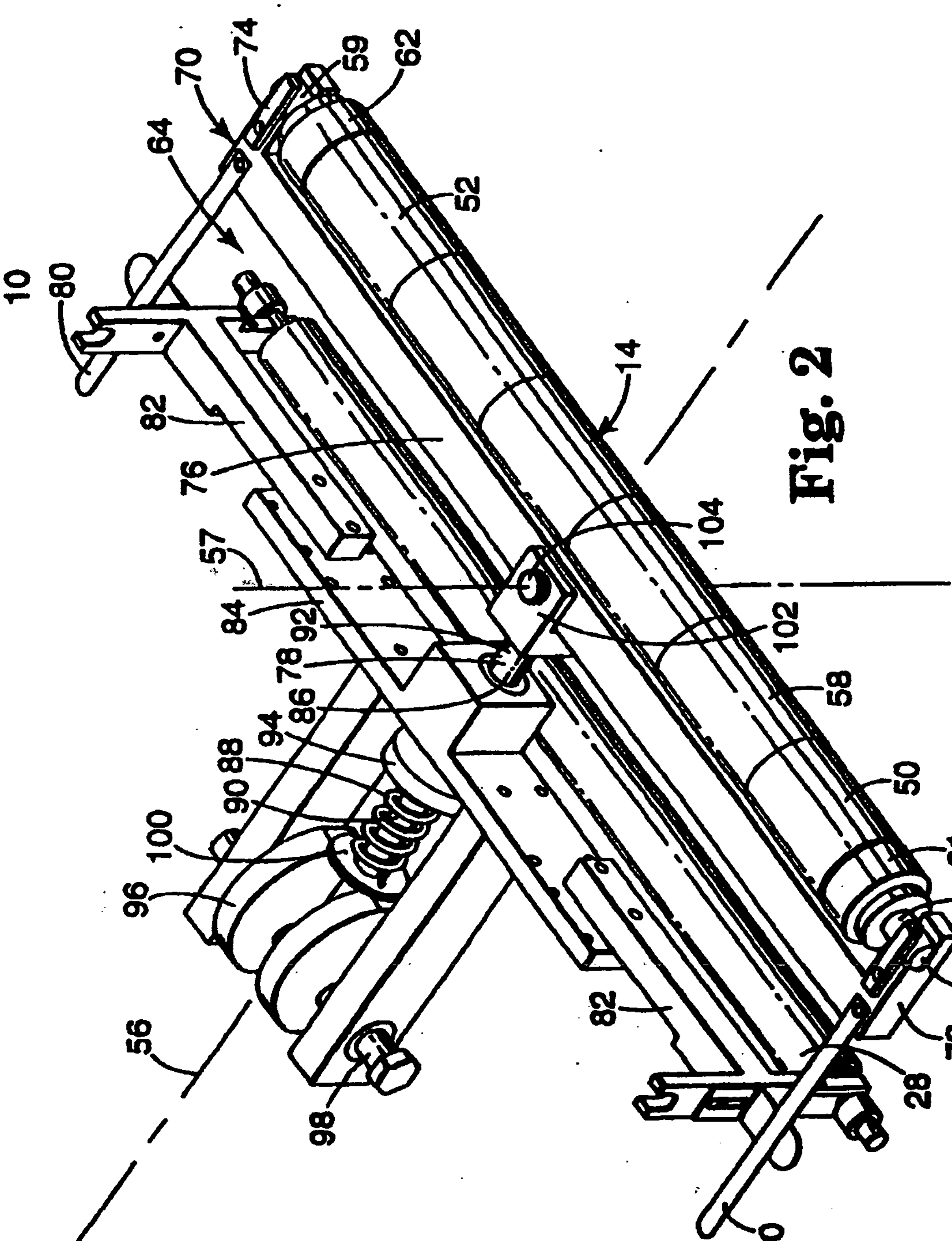
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Fig. 2

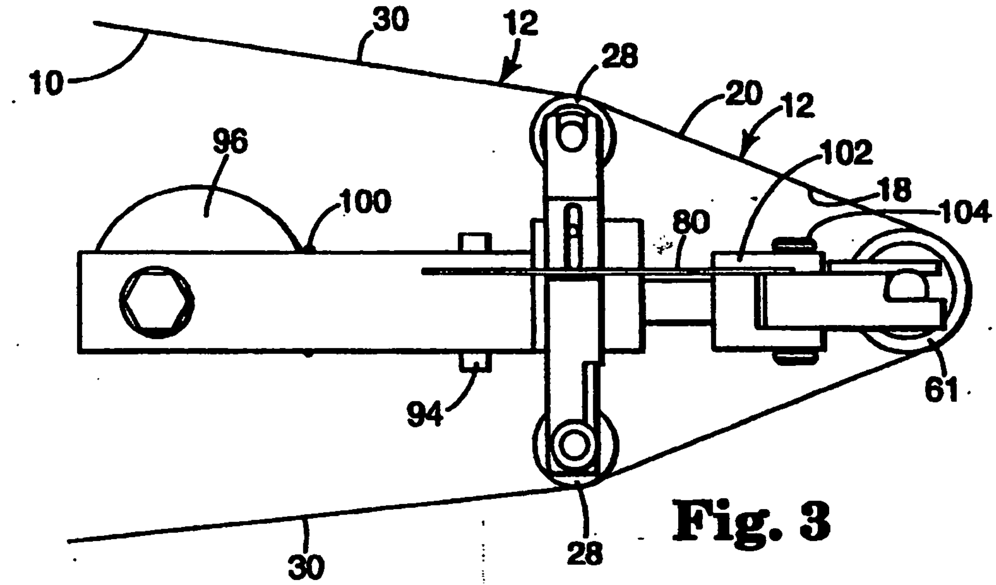

Fig. 3

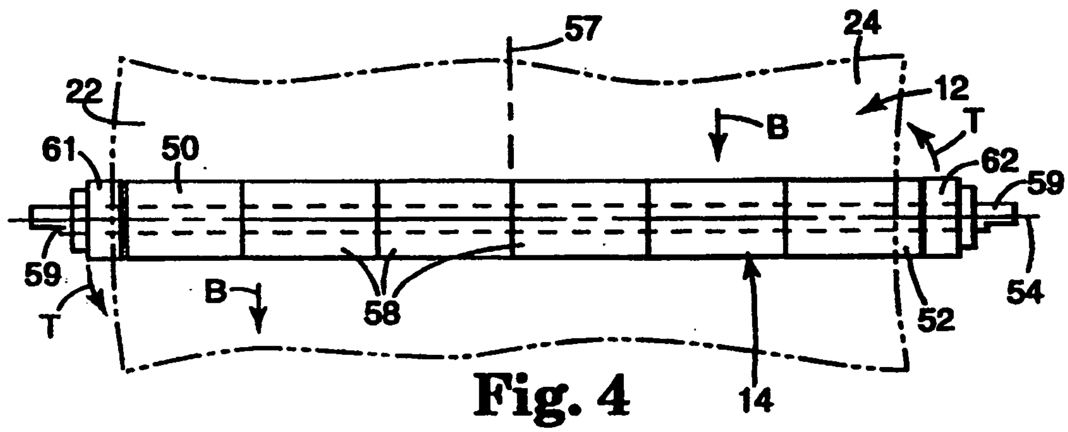

Fig. 4

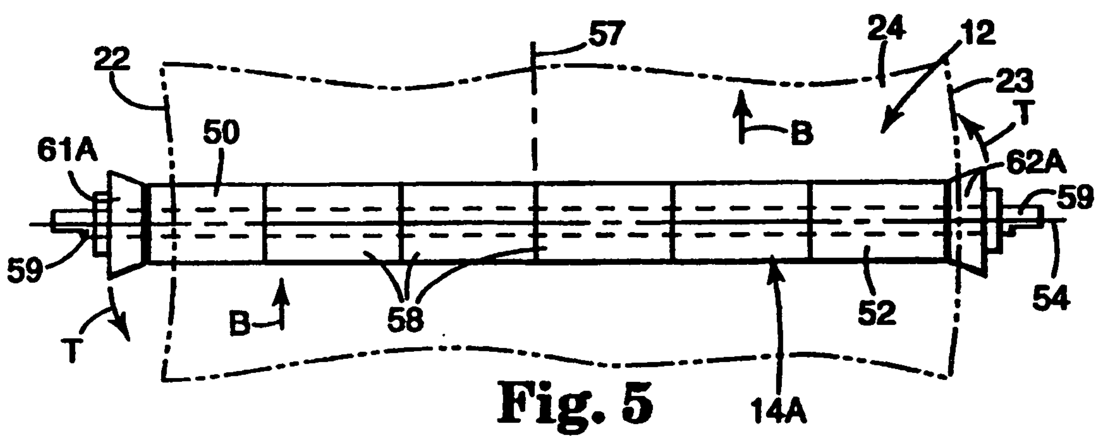

Fig. 5

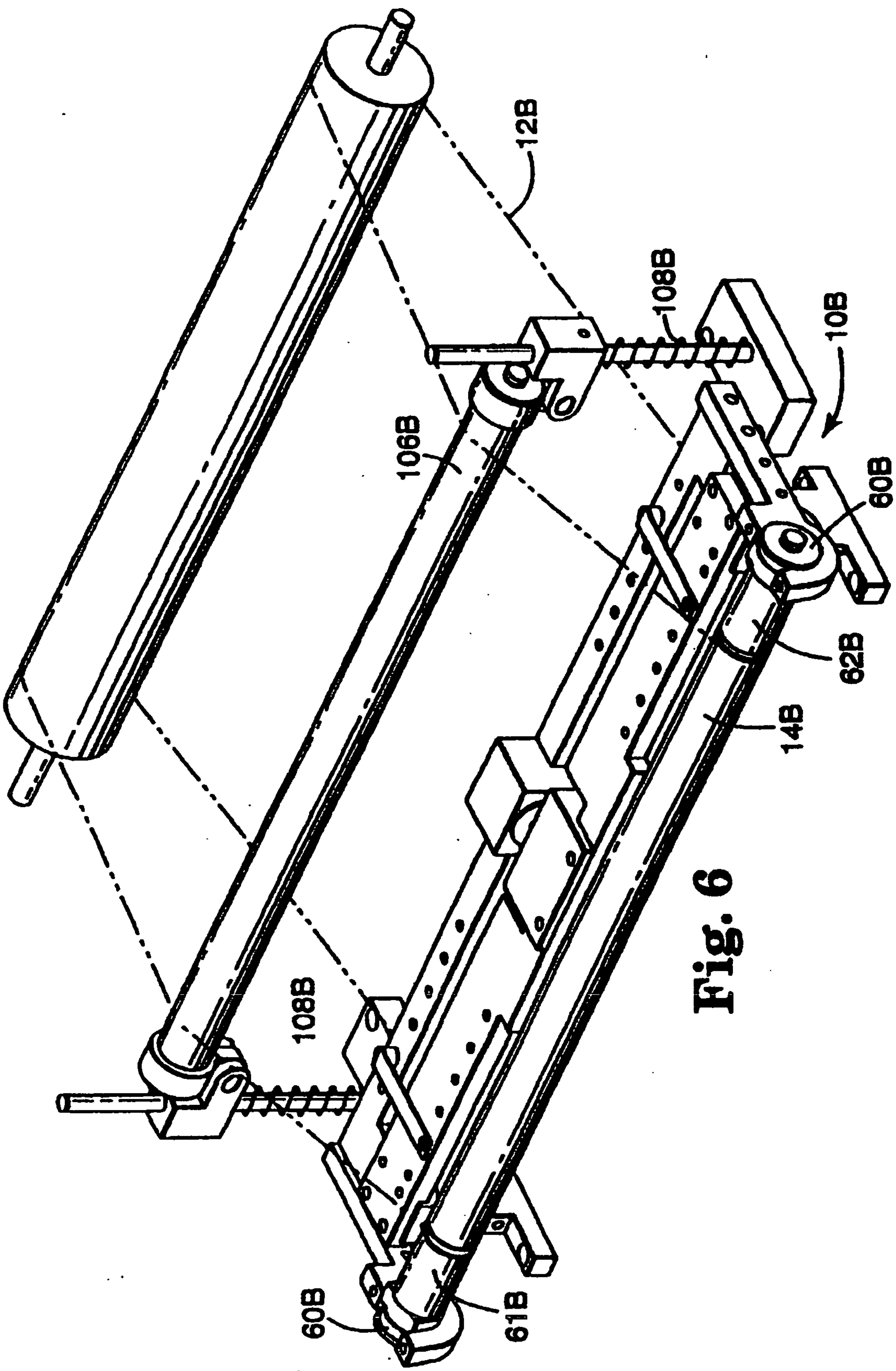

Fig. 6

APPARATUS AND METHOD FOR STEERING AN ENDLESS BELT

FIELD OF THE INVENTION

The present invention relates to apparatuses and methods for steering a belt with a transport mechanism and more particularly to apparatuses and methods for passively steering a belt within a transport mechanism.

BACKGROUND OF THE INVENTION

Endless belts are known to be useful for continuously transporting a material from one point to another. An endless belt is positioned around a set of rollers within a transporting mechanism, at least one of the rollers being driven to transport the belt around a transport loop. The rollers can be cantilever-supported, that is, each roller is being supported at only one end such that the endless belt can slide over the unsupported end for removal and replacement. More typically, the rollers are supported at both ends such that one end support on each of the rollers is removed when the endless belt is installed, replaced, etc.

An endless belt can be of a long, flexible strip of material in which the two ends are joined or seamed. For fabric-based belts, seaming includes stitching the two ends together. For thermoplastic material-based belts, seaming can include thermally bonding the two ends together. Other means for seaming include the use of adhesives and mechanical joints, such as zippers.

A specifically designed endless belt has been used within electrophotographic printers. The belt is made of a photoreceptive material which can electrostatically capture an image when exposed to an image-wise pattern of light at an imaging station. Once exposed, the belt is rotated adjacent to a toning station which applies toner to the belt. The toner is attracted to the electrostatic image within the belt such that the toner takes on substantially the same pattern as that created by the image-wise pattern of light (i.e., a toned image). As the belt rotates, the toned image is transferred by a transfer station to, for example, a blank sheet of paper. The belt is further rotated to a charging station which electrostatically "erases" remnants of the previously created electrostatic image. Further rotated, the belt can be charged to a potential which prepares the belt to capture a subsequent image. A complete rotation of the belt through this transport loop can be continuously and rapidly repeated (charge, expose, tone, transfer, erase, charge, . . .).

However, a challenge is associated with the use of an endless belt, which is keeping the belt properly aligned on the set of rollers. This challenge is magnified when the material being transported must be transported to a very specific location. Because an endless belt can begin to drift or walk from one lateral position on the rollers to another when one or more of the rollers apply a force unevenly across the width of the belt, steering mechanisms have been developed.

Designed to correct or counteract the drifting of the belt, known steering mechanisms have proven to be ineffective, cost-prohibitive, space-prohibitive, or a combination thereof. One known steering approach involves bending the belt in the plane in which the belt travels. For wider and stiffer belts, this approach can be ineffective.

Another known steering approach involves moving all of the rollers. However, for transport mechanisms which involve applying nip pressure to the belt, for example by an outer pressure roller and an inner back-up roller, steering by moving the inner back-up roller complicates the ability of that mechanism to apply continuous nip pressure.

Another approach for steering involves the use of one or more flared rollers to cause higher tension on one edge of the belt. Creating higher tension on one edge can cause the other edge to be unsupported or less supported which is not practical in particular processes, including certain printing processes. In addition, this approach can result in damage to the belt.

Another approach for maintaining the position of the belt involves rollers having end flanges or other end structures which can contact the edges of the belt. However, this approach can damage the edges of particularly susceptible belts.

Another known steering approach involves actively correcting the position of the belt on the rollers. Active correction systems include sensors, actuators, and control systems that can add to the cost and the space requirement of the steering architecture.

There is a need for a steering approach which is cost-effective and space-effective. In addition, that steering approach should work without the need for end flanges or flared rollers. Furthermore, that steering approach should be work even if a portion of the belt is nipped between two rollers.

SUMMARY OF THE INVENTION

The present invention involves a steering apparatus and method which fill this need. One embodiment includes an apparatus useful for maintaining an endless belt within a lateral target belt position range while the endless belt is transported by a transporting mechanism. The endless belt has a belt inner surface and a first belt edge. The apparatus includes a steering roller contacting the belt inner surface. The steering roller has a first roller end. A carriage supports the steering roller. The carriage is pivotable about a steering axis such that the steering roller is pivotable about the steering axis. A first member is positioned adjacent to the first roller end and functionally connected to the carriage. The first member contacts the belt inner surface when the first belt edge extends sufficiently beyond the first roller end. The first member applies greater friction to the endless belt than the steering roller when the belt contacts the first member. The first member is positioned relative to the steering axis such that contact between the first member and the belt causes the first member to apply a first torque to the carriage about the steering axis.

Another embodiment of the present invention includes an endless belt system. This system includes an endless belt which has a belt inner surface and a first belt edge. A drive roller contacts the endless belt. A belt-steering system includes a steering roller which contacts the belt inner surface. The steering roller has a first roller end. The belt-steering system also includes a carriage for supporting the steering roller. The carriage is pivotable about a steering axis such that the steering roller is pivotable about the steering axis. The belt-steering system also includes a first member positioned adjacent to the first roller end and functionally connected to the carriage. The first member contacts the belt inner surface when the first belt edge extends sufficiently beyond the first roller end. The first member applies greater friction to the endless belt than the steering roller when the belt contacts the first member. The first member is positioned relative to the steering axis such that contact between the first member and the belt causes the first member to apply a first torque to the carriage means about the steering axis.

Another embodiment of the present invention includes an electrophotographic system. This system includes an endless belt which has a first belt edge, a belt inner surface, and a belt outer surface. The belt outer surface includes a photoreceptive substrate. A charging system charges the photoreceptive substrate. An exposure system exposes the photoreceptive substrate to at least one image-wise pattern of radiation which creates at least one electrostatic image on the photoreceptive substrate. A development system develops the at least one electrostatic image to an at least one toned image. A transfer system transfers the toned image to a receptor. A belt-steering system steers the belt and includes a steering roller which contacts the belt inner surface. The steering roller has a first roller end. The belt-steering system includes a carriage for supporting the steering roller. The carriage is pivotable about a steering axis such that the steering roller is pivotable about the steering axis. The belt-steering system includes a first member positioned adjacent to the first roller end and functionally connected to the carriage. The first member contacts the belt inner surface when the first belt edge extends sufficiently beyond the first roller end. The first member applies greater friction to the endless belt than the steering roller when the belt contacts the first member. The first member is positioned relative to the steering axis such that contact between the first member and the belt causes the first member to apply a first torque to the carriage about the steering axis.

Another embodiment of the present invention includes a method useful for steering an endless belt toward a lateral target belt position while the endless belt is transported by a transporting mechanism. The endless belt has a belt inner surface and a first belt edge. The method includes the step of providing a steering roller which contacts the belt inner surface. The steering roller has a first roller end and is rotatable about a roller axis. A carriage supports the steering roller and is pivotable about a steering axis allowing the steering roller to be pivotable about the steering axis. Another step includes providing a first member which is positioned adjacent to the first roller end and functionally connected to the carriage. The first member contacts the belt inner surface when the first belt edge extends sufficiently beyond the first roller end. The first member applies greater friction to the endless belt than the steering roller when contacting the endless belt causing the endless belt to apply a first torque to the carriage about the steering axis.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing advantages, construction, and operation of the present invention will become more readily apparent from the following description and accompanying drawings.

FIG. 1 is a front view of a belt transporting mechanism which includes a steering apparatus in accordance with the present invention;

FIG. 2 is an isometric view of the steering apparatus shown in FIG. 1;

FIG. 3 is a front view of the steering apparatus shown in FIGS. 1 and 2;

FIG. 4 is a right side view of a portion of the steering apparatus shown in FIGS. 1–3;

FIG. 5 is a right side view of an alternative embodiment of the portion of the steering apparatus shown in FIG. 4; and

FIG. 6 is an isometric view of another embodiment of a belt transporting mechanism including another embodiment of the steering apparatus shown in FIGS. 1–4.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

An embodiment of an electrophotographic system 2 is generally shown in FIG. 1. The electrophotographic system 2 includes a charging system 3, an exposure system 4, a development system 5, a transfer system 6, and a belt steering system or apparatus 10, which includes an endless belt 12.

The endless belt 12 includes a photoreceptive substrate which can be electrostatically charged by the charging system 3. The exposure system 4 exposes the photoreceptive substrate of the belt 12 to at least one image-wise pattern of radiation which creates at least one electrostatic image on the photoreceptive substrate. The development system 5 develops the at least one electrostatic image to an at least one toned image by applying a toner to the photoreceptive substrate of the belt 12.

The term "toner" is generically used to mean a material such as a dry or powder toner or a liquid toner. It is meant to be sufficiently generic to cover materials which are known in the industry as "developers." A preferred example of the toner, however, is the liquid toner specifically covered in a pending U.S. patent application which is identified as 3M Docket No. 52069USA8A, filed by 3M Company, entitled "Liquid Inks Using A Gel Organosol" (Baker et al.). This application is hereby incorporated by reference.

The transfer system 6 transfers the toned image to a receptor 7. Examples of a relevant endless belt and a relevant electrophotographic system are described in greater detail in a pending patent application filed Sep. 29, 1995, assigned to 3M Company, designated as 3M Docket No. 51325USA4A, entitled "A Method and Apparatus for Producing a Multi-Color Image in an Electrophotographic System" (Kellie et al.). This pending patent application is hereby incorporated by reference.

Though useful for steering the endless belt 12 within the electrophotographic system 2, the apparatus 10 shown in FIGS. 1–4 is useful within a variety of other endless belt systems. The apparatus 10 passively controls the position of an endless belt 12 relative to a target belt position on a steering roller 14 while the endless belt 12 is transported by a number of roller making up a transporting mechanism 16. The apparatus 10 is capable of passively controlling the position of the belt 12 when the belt 12 is being transporting both the clockwise and counterclockwise directions, as per the perspective of FIG. 1.

When the belt 12 is acted upon by a force which causes the belt 12 to move, or walk, laterally on the steering roller 14, the apparatus 10 can stop the lateral motion and can cause the belt 12 to move laterally back toward the target belt position. The term "target belt position" can mean a particular lateral position on the steering roller 14 or a lateral position range on the steering roller 14. The target belt position can be the position where the belt 12 is roughly centered on the steering roller 14, but this is not necessary. FIG. 4 shows the belt 12 being positioned to the left of center relative to the steering roller 14, possibly due to the application of a lateral force on the belt 12.

The endless belt 12 has an inner belt surface 18 and an outer belt surface 20, a first belt edge 22, and a second belt edge 24. On the belt outer surface 20, the endless belt 12 includes means for electrostatically capturing an image corresponding to an image-wise pattern of radiation.

The belt 12 is shown contacting a number of rollers which constitute the transporting mechanism 16. The belt inner surface 18 is shown contacting a number of inner rollers including the steering roller 14, a drive roller 26, and two stabilizing rollers 28. The drive roller 26 is connected to a drive mechanism (not shown) which drives the endless belt around the transport loop created by the inner rollers. The

stabilizing rollers maintain the position of spans 30 of the belt 12 which may be necessary to the imaging process within an electrophotographic apparatus (or other apparatus).

The belt outer surface is shown as contacting an upper nip roller 31 and a lower nip roller 32, components of the transfer system 6. The upper and lower nip rollers 31, 32 can apply nip pressure to the belt 12 to transfer toner from the belt 12 to the upper nip roller 31. Within an imaging apparatus, such as the electrophotographic apparatus 2, still other rollers (not shown) can contact the belt inner and outer surfaces 18, 20 and can apply nip pressure to the belt 12. Uneven nip pressure, like belt non-squareness and roller misalignment, can cause the belt 12 to walk laterally on the inner rollers.

The endless belt 12 can be relatively inelastic and relatively wide and still passively steered by the apparatus 10. One embodiment of the belt 12 is polyester film-based (0.004-inch thick (0.010-centimeter)). The circumference of the belt 12 is between approximately 24 and 40 inches (approximately 61 and 102 centimeters). The width of the belt 12 is between approximately 9.5 and 14 inches (approximate 24 and 36 centimeters). The width of the belt 12 can be the same as the width of the steering roller 14, although it could be narrower or wider. The belt length-to-width ratio is typically between approximately 2.5 and 3.5. The modulus of the belt 12 is approximately 450,000 pounds per square inch (3.1×10^9 Newtons per square meter).

The steering roller 14 includes a roller first end 50 and a roller second end 52. The steering roller 14 is shown in FIG. 2 as being cylindrical in shape and rotatable about a roller axis 54, and being pivotable about a steering axis 56 and about a tension-balancing axis 57. The roller axis 54 is shown as being perpendicular to the steering axis 56 and the tension-balancing axis 57. The roller axis 54 is shown as intersecting the steering axis 56 (coplanar), but not intersecting the tension-balancing axis 57 (non-coplanar). This relationship of the axes 54, 56, 57 may be preferred, but other relationships are envisioned.

The steering roller 14 is shown as including more than one cylindrical collar 58 which ride and rotate on an internal dead shaft 59. While the steering roller 14 can be made of one cylindrical collar 58, a plurality of collars 58 results in reduced rotational drag being applied to the belt 12 by the steering roller 14 when the steering roller 14 pivots sufficiently about the steering axis 56. Another embodiment of the steering roller 14B (shown in FIG. 6, and discussed further below) could include a single rotating, cylindrical member which is supported at its ends with roller bearings 60B.

A first member 61 is positioned adjacent to the first roller end 50 and a second member 62 is positioned adjacent to the second roller end 52. As shown in FIG. 3, the first member 61 contacts the belt inner surface when the endless belt moves or walks from the target belt position and the first belt edge 18 extends sufficiently beyond the first roller end 50. Conversely, the second member 62 contacts the belt inner surface when the endless belt moves or walks from the target belt position and the second belt edge 20 extends sufficiently beyond the second roller end 52. The inclusion of both the first and the second members 60, 62 allows for a bi-lateral belt steering capability. Another embodiment of the apparatus 10 could including only one of the two members 60, 62 and allow for a unilateral belt steering capability.

FIGS. 2 and 4 show the first and second members 61, 62 as being cylindrical in shape and having an outer diameter which is approximately the same as the outer diameter of the steering roller 14. The belt 12 is shown as having moved laterally to contact the first member 61. Due to the transport direction of the belt (indicated by arrow B) and due to the position of the first member 61 relative to the steering axis 56, Arrow T indicates the direction of the torque that is applied by the belt 12 to the carriage 70. The creation of this torque is described later within this disclosure.

FIG. 5 shows another embodiment of the first and second members 61A, 62A. In this embodiment, the first and second members 61A, 62A are frustoconical in shape, rather than cylindrical. The outer diameter of the first and second members 61A, 62A adjacent to the steering roller 14A can be smaller than the outer diameter of the steering roller 14A such that the belt first and second edges 22A, 24A do not contact this portion of the first and second members 61A, 62A.

Because of the frustoconical shape, the outer diameter of the first and second members 61A, 62A at the opposite end of the first and second members 61A, 62A is larger than the outer diameter of the steering roller 14. Consequently, the belt 12A contacts the first member 61A or the second member 62A after sufficiently walking beyond the first roller end 50A or the second roller end 52A, respectively. This approach minimizes the chance of either first belt edge 22A or the second belt edge 24A contacting and being damaged by the vertical face of the first member 61A or the second member 62A, respectively. In addition, the increase in the outer diameter of the first and second members 61A, 62A is kept sufficiently small to not create a high tension on the belt edges 21A, 22A, thereby further minimizing the chances of damaging the belt 12 (i.e., avoiding the problem caused by a flared steering roller).

FIG. 5 also shows the belt 12 as having moved laterally to contact the second member 62A and as being transported in an opposite direction to that shown in FIG. 4. Due to the transport direction B of the belt 12 and the position of the second member 62A relative to the steering axis 56, arrow T shows the direction of the torque applied by the belt 12 to the carriage 70.

FIGS. 4 and 5 each illustrate an embodiment which is capable of steering the belt 12 when the belt 12 is forced to either side of the steering roller 14. In addition, these figures also illustrate that these embodiments are effective when the belt 12 is transported in either direction by the transporting mechanism 16. This can be important for systems which require the belt 12 to reverse directions.

The first and second members 61, 61A, 62, 62A can be made of a relatively high friction material or include a high friction material on the surface which contacts the belt 12. Examples of such a material is black electrical tape (made by 3M Company, St. Paul, Minn.) and Tygon-brand tubing F-4040-A (made by Norton Performance Plastics Corporation, Akron, Ohio).

In FIGS. 1–4, a carriage 70 is shown supporting the steering roller 14 and the first and second members 61, 62 allowing the steering roller 14 and the first and second members 61 to pivot on the steering axis 56. The carriage 70 is shown in FIGS. 1–4 as including a carriage first end member 72, carriage second member 74, carriage center member 76, and a carriage pin 78. The carriage pin 78 having a longitudinal axis about which it can rotate, the longitudinal axis being the steering axis 56.

Flat springs 80 are shown in FIGS. 1–4 being attached to the carriage 70 and being biased against extending members 82 which extend from a support block 84. The flat springs 80

resist the pivoting of the carriage 70 and the steering roller 14 around the steering axis 56, and can restore the carriage 70 to a particular position on the steering axis 56. Other pivot resisting means, such as other spring types, could be employed in place of the flat springs 80.

The support block 84 can be attached and stationary relative to the larger apparatus (not shown) of which the apparatus 10 is a part. A journal beating 86 is located at the approximate center of the support block 84. The journal bearing 86 constrains the carriage pin 78, but allows the carriage pin 78 to rotate about the steering axis 56 and translate axially on the steering axis 56. The combination of a radial bearing (not shown) and a linear bearing (not shown) could be used in place of the journal bearing.

The steering roller 14 can be configured to spin freely (or spin with relatively little friction) about the roller axis 54. The first member 61 and the second member 62 can be configured to be non-rotating about the roller axis 54 (by being, for example, attached to the dead shaft with a set screw). Or, the first and second member 61, 62 can be configured to spin with significantly more resistance than the steering roller 14. Consequently, the first and second members 61, 62 apply greater friction to the belt 12 when contacting the belt 12 than is applied by the freely rotating steering roller 14.

As a result, when the belt 12 walks laterally over the steering roller 14, for example, such that the first belt edge 22 extends beyond the first roller end 50 and contacts the first member 61 the belt 12 will drag on the first member 61 and apply a frictional force to the first member 61. Due to the position of first member 61 relative to the steering axis 56 and due to the direction of the frictional force on the first member 61, the belt 12 applies a pivoting torque to the carriage 70 about the steering axis. When the pivoting torque applied by the belt 12 to the carriage 70 is sufficiently large, the cartage 70 and the steering roller 14 will pivot about the steering axis 56 (in a counterclockwise direction about the steering axis 56 from the perspective provided by FIG. 4 when the belt 12 is transported in a clockwise direction from the perspective provided in FIG. 1). Based on this belt direction and from the perspective provided by FIG. 4, the first roller end 50 will be pivoted downwardly relative to the second roller end 52.

A sufficiently large pivoting torque would be a torque which is sufficient to overcome anything which resists pivoting, including the torque due to the flat springs 80 and the resistance of the belt 12 to stretch (i.e., belt modulus). The sufficiently large pivoting torque will cause the carriage 70 to continue to pivot until the sufficiently large pivoting torque is exceeded by the resistance of the flat springs 80 and the stretch resistance of the belt 12 (and any other pivot resistance).

When pivoted and misaligned relative to the other rollers contacting the belt inner surface, the steering roller 14 applies an uneven force or a steering force against the belt 12 in a direction opposite to the walking direction. The magnitude of the steering force is related to the degree to which the steering roller 14 is pivoted. The belt 12 will continue to walk laterally until the steering force overcomes the walking force (i.e., the force which caused the belt 12 to walk, for example, the force resulting from belt non-squareness, roller misalignment, and/or uneven nip pressure).

If the walking force continues to be applied to the belt 12, the carriage 70 and the steering roller 14 will come to a stable pivotal position on the steering axis 56 where the

steering force balances with the walking force. Because the walking force may not be constant, the stable pivotal position may also not be constant. Consequently, the steering roller 14 may occasionally or continually adjust to counter the walking force.

The previous paragraphs refer to movement of the belt 12 toward the first member 61 (like that shown in FIG. 4). However, the same result is brought about when the belt 12 makes sufficient contact with the second member 62 (as is shown in FIG. 5). The belt 12 will drag on the second member 62 causing the second member 62 to move downwardly relative to the first member 61 causing the steering roller 14 to pivot (in a clockwise direction from the perspective provided by FIG. 4). The steering roller 14 will pivot to a stable pivotal position similarly to that described above.

For the steering roller 14 to steer the belt 12, the belt 12 must be under sufficient tension. The apparatus 10 provides means for applying the adequate tension to the belt 12 and means for balancing the tension across the width of the belt 12 even when the steering roller 12 is pivoted from its neutral position. This tension-balancing means also compensates for roller misalignment and belt non-squareness.

The tension-balancing means can include a coil spring 88 which is shown positioned around the pin second end 90 (the pin first end 92 adjacent to the carriage center member 76) and compressed between a face of a tension-adjusting disc 94 and a tension-releasing cam 96. The tension-releasing cam 96 is rotatable about a cam pin 98 from a tension-engaging position to a tension-releasing position. This enables a user to quickly engage or release the tension applied by the coil spring 88. A washer 100 is shown between the tension-releasing cam 96 and the coil spring 88.

The tension-adjusting disc is internally threaded and mated to an externally threaded portion of the pin second end 90. The tension-adjusting disc 94 can be rotated around the pin second end 90 to compress the coil spring 88 to set the tensioning force. The coil spring 88 biases the carriage pin 78 toward the steering roller 14 with a tensioning force proportional to the degree to which the coil spring 88 is compressed.

The pin first end 92 is shown connected to a carriage coupling member 102 which is positioned around a portion of the carriage center member 76. Aligned holes through both the carriage coupling member 102 and the carriage center member 76 allow a coupling pin 104 to join the carriage coupling member 102 to the carriage center member 76. The diameter of the coupling pin 104 can be such that it is pressfit within the hole in the carriage coupling member 102. But, the diameter of the coupling pin 104 can be such that carriage center member 76 (and the steering roller 14) can rotate about the axis of the carriage coupling pin 104, that axis being the tensioning axis 57.

As a result of this ability to rotate about the tension-balancing axis 57, the steering roller 14 can pivot in a horizontal plane (per FIG. 1–4) when the steering roller pivots in the vertical plane about the steering axis 56. Consequently, the tensioning force created by the coil spring 88 is balanced across the width of the steering roller 14.

In addition to contributing to the tension-balancing effect, the coil spring 88 contributes to the pivot-resisting effect. When the belt 12 drags on the first or second member 61, 62 and causes the steering roller 14 to pivot on the steering axis 56, the coil spring 88 is compressed further. As the coil spring 88 is compressed further, the coil spring 88 has a greater potential energy and applies a greater force to the

carriage 70 increasing the tension within the belt 12 (which increases the potential energy). Consequently, the coil spring 88 should be considered another means for resisting pivoting of the steering roller 12 about the steering axis 56.

FIG. 6 illustrates another embodiment in which the steering ability and the tensioning ability are split into two rollers rather than relying only on the steering roller 14B. In this embodiment, the steering roller 14B has the ability to pivot about the belt steering axis 56B. A tension roller 106B adjacent to the steering roller 14B includes two ends which can be independently biased against the belt 12B to maintain tension across the belt 12B even when the steering roller 14B pivots about the steering axis 56B. Coil tension springs 108B are shown biasing the tension roller 106B against the belt 12B.

Many other configurations of the apparatus 10 are envisioned to provide similar results. For example and as previously mentioned, the apparatus 10 can be used in a unilateral steering capacity. That is, the belt 12 could intentionally be driven to one side of the steering roller 14 by canting an adjacent roller (such as one of the stabilizing roller 28 shown in FIG. 1). This would require the steering apparatus 10 to steer the belt 12 only in one direction, which can be a means for simplifying the steering apparatus 10. In addition, the belt-tensioning means could include, for example, an air-cylinder rather than or in addition to the coil spring. The air-cylinder could also be used in place of the tensioning-release cam. Accordingly, many other variations fall within the scope of this invention.

We claim:

1. An apparatus useful for maintaining an endless belt within a lateral target belt position range while the endless belt is transported by a transporting mechanism, the endless belt having a belt inner surface and a first belt edge, the apparatus comprising:

- a steering roller contacting the belt inner surface, the steering roller having a first roller end;
- carriage means for supporting the steering roller, the carriage means being pivotable about a steering axis such that the steering roller is pivotable about the steering axis;
- a first member positioned adjacent to the first roller end and functionally connected to the carriage means, the first member contacting the belt inner surface when the first belt edge extends sufficiently beyond the first roller end, the first member applying greater friction to the endless belt than the steering roller when the belt contacts the first member, the first member being positioned relative to the steering axis such that contact between the first member and the belt causes the first member to apply a first torque to the carriage means about the steering axis, the first member being configured such that first torque is sufficient to cause the steering roller to pivot around the steering axis; and
- pivot-resisting means for resisting the pivoting of the steering roller about the steering axis, the pivot-resisting means being functionally connected to the carriage means.

2. An apparatus useful for maintaining an endless belt within a lateral target belt position range while the endless belt is transported by a transporting mechanism, the endless belt having a belt inner surface and a first belt edge, the apparatus comprising:

- a steering roller contacting the belt inner surface, the steering roller having a first roller end;
- carriage means for supporting the steering roller, the carriage means being pivotable about a steering axis such that the steering roller is pivotable about the steering axis; and
- a first member positioned adjacent to the first roller end and functionally connected to the carriage means, the first member being cylindrical and non-rotating, the first member contacting the belt inner surface when the first belt edge extends sufficiently beyond the first roller end, the first member applying greater friction to the endless belt than the steering roller when the belt contacts the first member, and the first member being positioned relative to the steering axis such that contact between the first member and the belt causes the first member to apply a first torque to the carriage means about the steering axis.

3. An apparatus useful for maintaining an endless belt within a lateral target belt position range while the endless belt is transported by a transporting mechanism, the endless belt having a belt inner surface and a first belt edge, the apparatus comprising:

- a steering roller contacting the belt inner surface, the steering roller having a first roller end and comprising at least one steering cylindrical collar which is rotatable about a stationary shaft;
- carriage means for supporting the steering roller, the carriage means being pivotable about a steering axis such that the steering roller is pivotable about the steering axis; and
- a first member positioned adjacent to the first roller end and functionally connected to the carriage means, the first member contacting the belt inner surface when the first belt edge extends sufficiently beyond the first roller end, the first member applying greater friction to the endless belt than the steering roller when the belt contacts the first member, and the first member being positioned relative to the steering axis such that contact between the first member and the belt causes the first member to apply a first torque to the carriage means about the steering axis.

4. The apparatus of claim 3, the steering roller comprising between two and six steering cylindrical collars.

5. An apparatus useful for maintaining an endless belt within a lateral target belt position range while the endless belt is transported by a transporting mechanism, the endless belt having a belt inner surface and a first belt edge, the apparatus comprising:

- a steering roller contacting the belt inner surface, the steering roller being cylindrical and having a first outer diameter and a first roller end;
- carriage means for supporting the steering roller, the carriage means being pivotable about a steering axis such that the steering roller is pivotable about the steering axis; and
- a first member positioned adjacent to the first roller end and functionally connected to the carriage means, the first member contacting the belt inner surface when the first belt edge extends sufficiently beyond the first roller end, the first member applying greater friction to the endless belt than the steering roller when the belt contacts the first member, the first member being positioned relative to the steering axis such that contact between the first member and the belt causes the first member to apply a first torque to the carriage means about the steering axis, the first member being generally frustoconical and having a first member first end and a first member second end, the first member first end being adjacent to the first roller end and having a

second outer diameter, the first member second end having a third outer diameter, the second outer diameter being no larger than the first outer diameter, the third outer diameter being larger than the first outer diameter.

6. An apparatus useful for maintaining an endless belt within a lateral target belt position range while the endless belt is transported by a transporting mechanism, the endless belt having a belt inner surface and a first belt edge, the apparatus comprising:

a steering roller contacting the belt inner surface, the steering roller having a first roller end, the steering roller being rotatable about a roller axis;

carriage means for supporting the steering roller, the carriage means being pivotable about a steering axis such that the steering roller is pivotable about the steering axis, the steering axis not intersecting the roller axis; and

a first member positioned adjacent to the first roller end and functionally connected to the carriage means, the first member contacting the belt inner surface when the first belt edge extends sufficiently beyond the first roller end, the first member applying greater friction to the endless belt than the steering roller when the belt contacts the first member, the first member being positioned relative to the steering axis such that contact between the first member and the belt causes the first member to apply a first torque to the carriage means about the steering axis.

7. An apparatus useful for maintaining an endless belt within a lateral target belt position range while the endless belt is transported by a transporting mechanism, the endless belt having a belt inner surface and a first belt edge, the apparatus comprising:

a steering roller contacting the belt inner surface, the steering roller having a first roller end and a second roller end;

carriage means for supporting the steering roller, the carriage means being pivotable about a steering axis such that the steering roller is pivotable about the steering axis, the carriage means comprising:

a carriage first end member functionally connected to the first roller end;

a carriage second end member functionally connected to the second roller end;

a carriage center member functionally connected to the carriage first and second end members; and

a carriage pin having a first pin end, the first pin end being functionally connected to the carriage center member, the carriage pin having a pin longitudinal axis which is the steering axis, the carriage pin being rotatable about the pin longitudinal axis such that the steering roller and the carriage means are rotatable about the steering axis;

a first member positioned adjacent to the first roller end and functionally connected to the carriage means, the first member contacting the belt inner surface when the first belt edge extends sufficiently beyond the first roller end, the first member applying greater friction to the endless belt than the steering roller when the belt contacts the first member, the first member being positioned relative to the steering axis such that contact between the first member and the belt causes the first member to apply a first torque to the carriage means about the steering axis; and

pivot-resisting means for resisting the pivoting of the steering roller about the steering axis.

8. The apparatus of claim 7, the support block being stationary, the pivot-resisting means comprising at least one flat spring, the at least one flat spring having a first spring end and a second spring end, the first spring end being functionally connected to one of the first and the second carriage end members, the second spring end being positioned to contact the support block and resist the pivoting of the steering roller about the steering axis.

9. The apparatus of claim 8, the at least one flat spring comprising a first flat spring and a second flat spring, the first flat spring being functionally connected to the first carriage end member, and the second flat spring being functionally connected to the second carriage end member.

10. The apparatus of claim 7, the pivot-resisting means comprising a coil spring positioned around a portion of the carriage pin.

11. An apparatus useful for maintaining an endless belt within a lateral target belt position range while the endless belt is transported by a transporting mechanism, the endless belt having a belt inner surface, a first belt edge, and a belt width, the apparatus comprising:

a steering roller contacting the belt inner surface, the steering roller having a first roller end and a second roller end;

carriage means for supporting the steering roller, the carriage means being pivotable about a steering axis such that the steering roller is pivotable about the steering axis, the carriage means comprising:

a carriage first end member functionally connected to the first roller end;

a carriage second end member functionally connected to the second roller end;

a carriage center member functionally connected to the carriage first and second end members; and

a carriage pin having a first pin end, the first pin end being functionally connected to the carriage center member, the carriage pin having a pin longitudinal axis which is the steering axis, the carriage pin being rotatable about the pin longitudinal axis such that the steering roller and the carriage means are rotatable about the steering axis;

a first member positioned adjacent to the first roller end and functionally connected to the carriage means, the first member contacting the belt inner surface when the first belt edge extends sufficiently beyond the first roller end, the first member applying greater friction to the endless belt than the steering roller when the belt contacts the first member, the first member being positioned relative to the steering axis such that contact between the first member and the belt causes the first member to apply a first torque to the carriage means about the steering axis;

a belt-tensioning means for causing the steering roller to apply a tensioning force against the belt inner surface; and

a tension-balancing means for allowing the belt-tensioning means to balance the tensioning force across the belt width.

12. The apparatus of claim 11, the carriage pin having a second pin end, the second pin being threaded, the belt tensioning means comprising:

a compression spring positioned around the second pin end and having a first spring end; and

a tension adjustment disc having a spring face and a threaded inner surface, the spring face contacting the first spring end, the threaded inner surface mating with

roller end, the first member applying greater friction to the endless belt than the steering roller when the belt contacts the first member, the first member being positioned relative to the steering axis such that contact between the first member and the belt causes the first member to apply a first torque to the carriage means about the steering axis; and

a tension roller positioned adjacent to the steering roller, the tension roller applying a tensioning force to the belt inner surface.

21. An apparatus useful for maintaining an endless belt within a lateral target belt position range while the endless belt is transported by a transporting mechanism and while an image is imposed on the belt by an imaging station, the endless belt having a belt inner surface and a first belt edge, the apparatus comprising:

a steering roller contacting the belt inner surface, the steering roller having a first roller end;

carriage means for supporting the steering roller, the carriage means being pivotable about a steering axis such that the steering roller is pivotable about the steering axis;

a first member positioned adjacent to the first roller end and functionally connected to the carriage means, the first member contacting the belt inner surface when the first belt edge extends sufficiently beyond the first roller end, the first member applying greater friction to the endless belt than the steering roller when the belt contacts the first member, the first member being positioned relative to the steering axis such that contact between the first member and the belt causes the first member to apply a first torque to the carriage means about the steering axis; and

a stabilizing roller contacting the endless belt and positioned between the steering roller and the imaging station to create a span of the belt which forms a plane, the plane being substantially unaffected by pivoting movement of the steering roller.

22. A method useful for steering an endless belt toward a lateral target belt position while the endless belt is transported by a transporting mechanism, the endless belt having a belt inner surface and a first belt edge, the method comprising the steps of:

providing a steering roller contacting the belt inner surface, the steering roller having a first roller end, the steering roller being rotatable about a roller axis;

providing carriage means for supporting the steering roller, the carriage means being pivotable about a steering axis and allowing the steering roller to be pivotable about the steering axis;

providing a first member positioned adjacent to the first roller end and functionally connected to the carriage means, the first member contacting the belt inner surface when the first belt edge extends sufficiently beyond the first roller end, the first member applying greater friction to the endless belt than the steering roller when contacting the endless belt causing the endless belt to apply a first torque to the carriage means about the steering axis;

transporting the endless belt in a first direction; and

transporting the endless belt in a second direction opposite the first direction.

* * * * *

United States Patent [19]
Morse

[11] 3,913,813
[45] Oct. 21, 1975

[54] WEB SUPPORT WITH CASTERED AND GIMBALLED ROLLER

[75] Inventor: John E. Morse, Rochester, N.Y.

[73] Assignee: Eastman Kodak Company, Rochester, N.Y.

[22] Filed: Sept. 10, 1974

[21] Appl. No.: 504,777

[52] U.S. Cl. 226/21; 226/192
[51] Int. Cl.[2] B65H 25/26
[58] Field of Search 226/3, 15, 18, 19, 21, 226/192, 194

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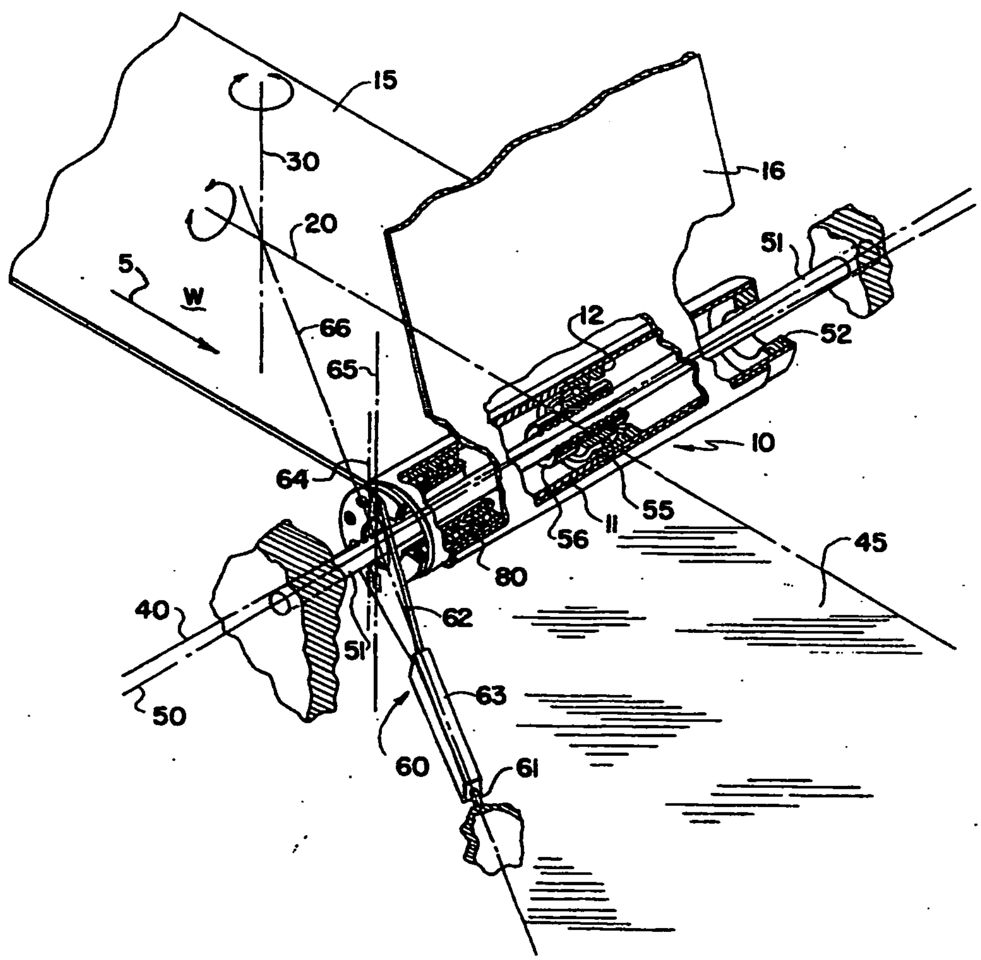
Primary Examiner—Richard A. Schacher
Attorney, Agent, or Firm—J. A. Mathews

[57] ABSTRACT

Web support for engaging a fully constrained moving web, having a cylindrical roller which imposes no lateral constraint on the entering portion of the moving web and which angularly decouples the exiting portion of the moving web. An improved mounting mechanism dynamically supports the roller solely at its midpoint along a fixed shaft. A constraining member reduces the movement of the roller to rotation about the longitudinal axis, pivotal movement about a gimbal axis which is parallel to the plane of the entering web portion of the moving web and perpendicular to and intersects the longitudinal axis at the midpoint of the roller, pivotal movement about a castering axis which is substantially perpendicular to the plane of the entering web portion of the moving web and intersects the gimbal axis at a point upstream from the midpoint of the roller, and translational movement along the fixed shaft as required for pivotal movement about the castering axis.

5 Claims, 6 Drawing Figures



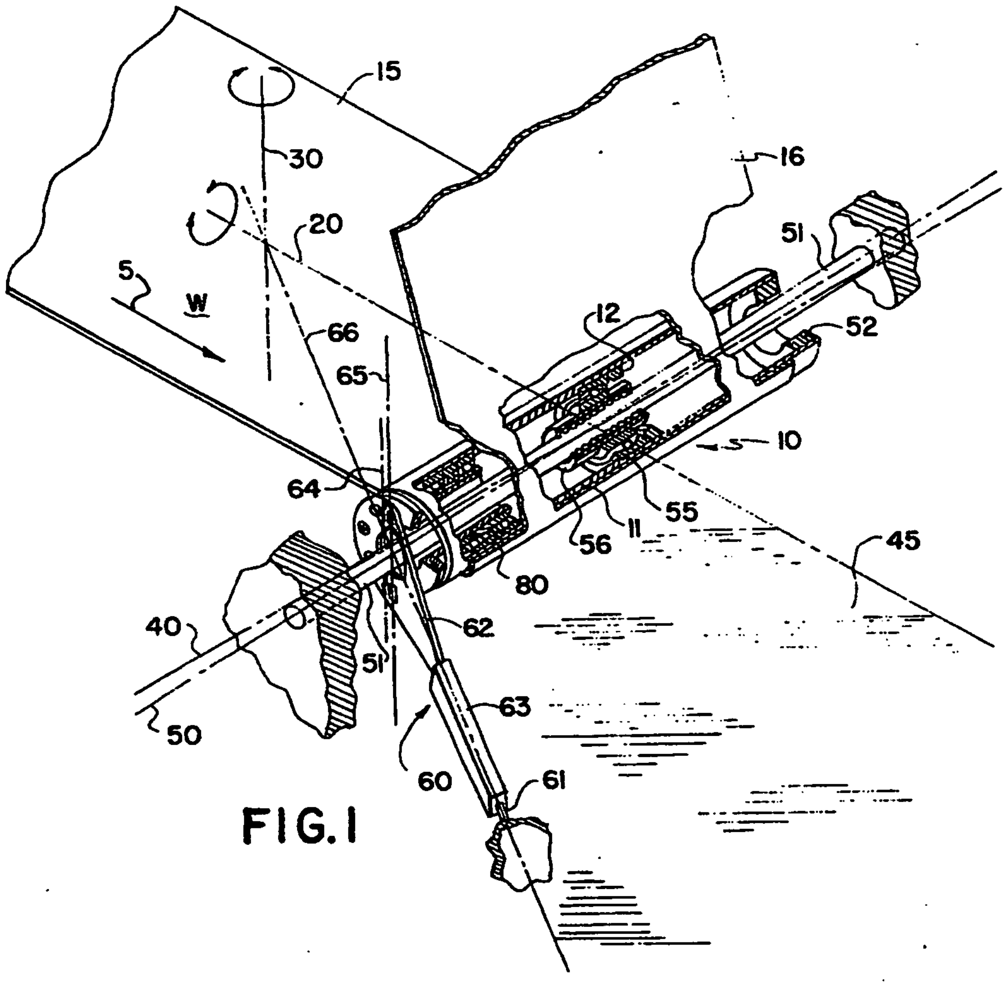

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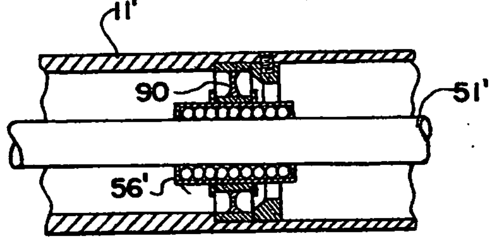
FIG. 1

FIG. 2c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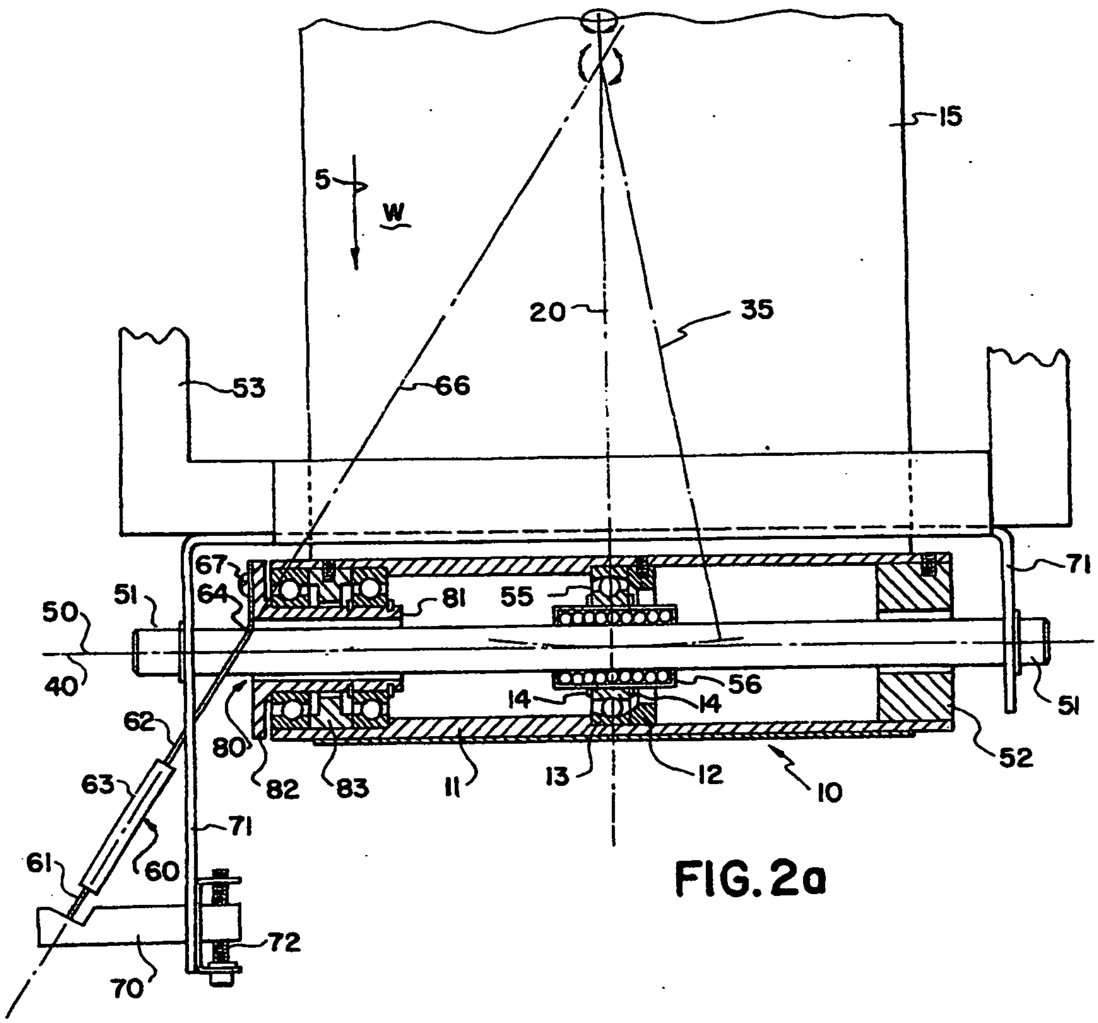

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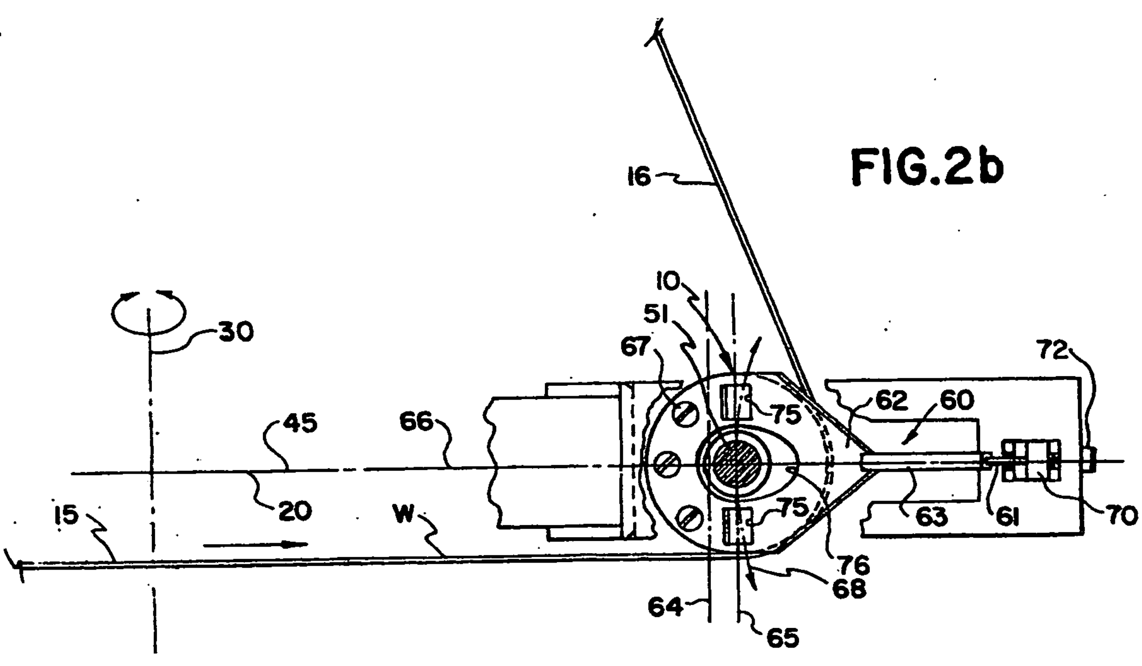
FIG. 2a



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64
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FIG. 2b

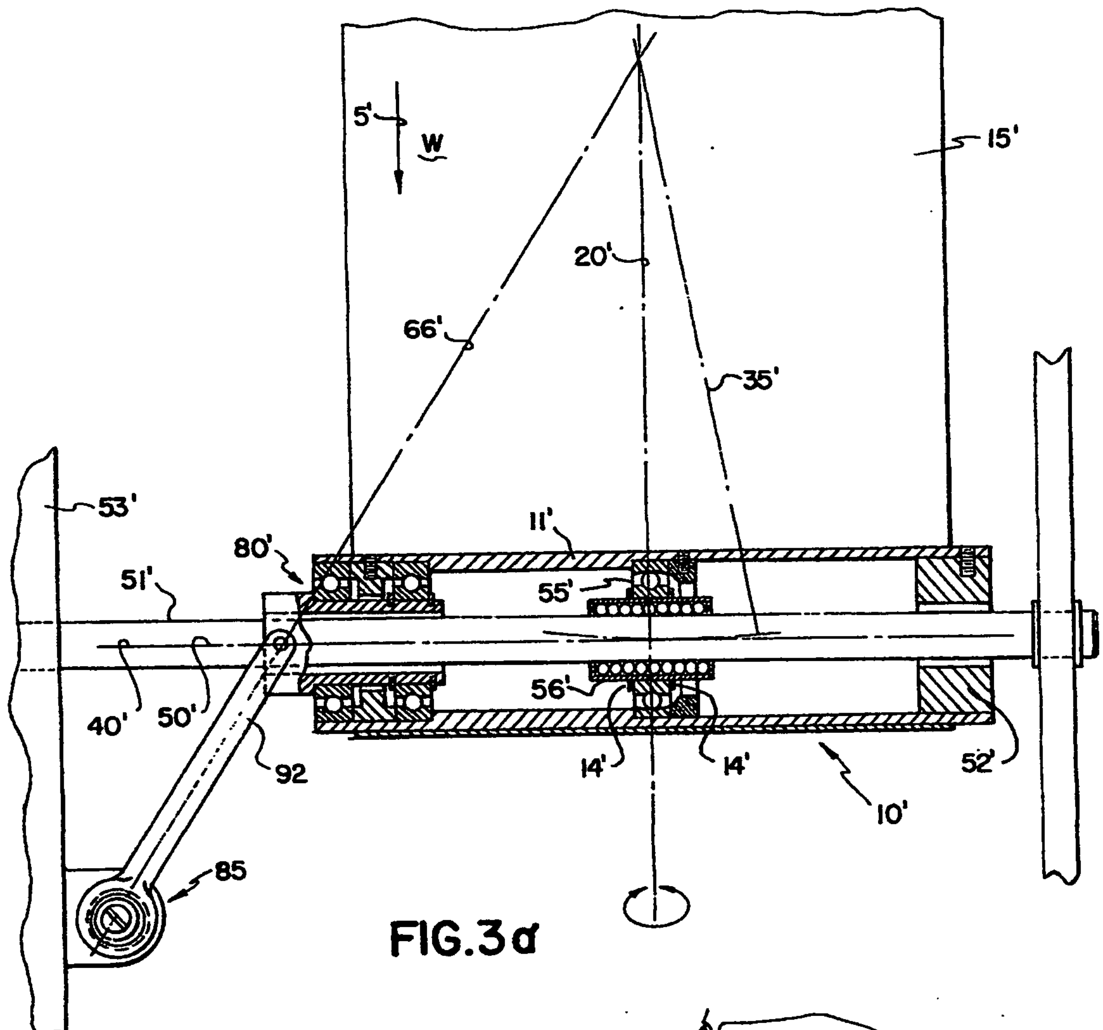
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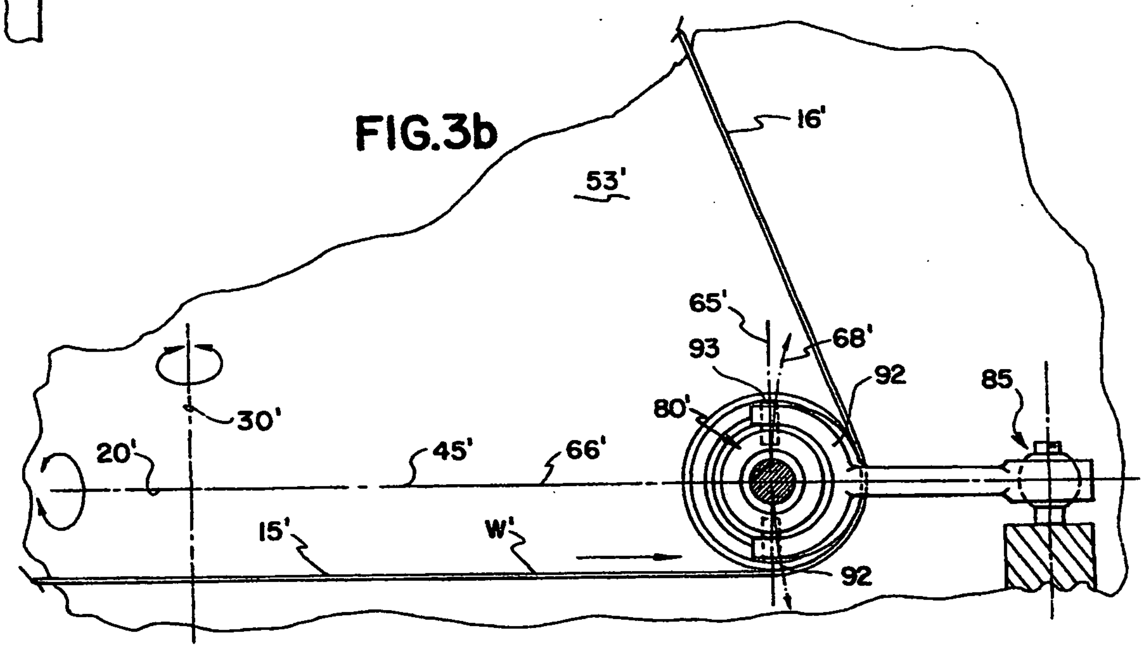
FIG.3a

FIG.3b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W'
92

WEB SUPPORT WITH CASTERED AND GIMBALLED ROLLER

CROSS-REFERENCE TO RELATED APPLICATIONS

Reference is hereby made to commonly assigned and copending U.S. Pat. application Ser. No. 504,771, filed Sept. 10, 1974, entitled WEB TRACKING APPARATUS, filed on even data herewith in the names of Thaddeus Swanke, Michael Samuel Montalto, and John Edwin Morse. Reference is also made to commonly assigned and copending U.S. Pat. application Ser. No. 504,778 filed Sept. 10, 1974, entitled POSITIONALLY CONSTRAINING WEB SUPPORT, filed on even data herewith, in the names of Thaddeus Swanke and Richard Thomas O'Marra.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to a web handling device, and more specifically to a mounting mechanism for a web engaging roller in a web support which imposes no lateral constraint to the entering web portion and which angularly decouples the exiting web portion.

2. Description of the Prior Art

Web tracking apparatus for tracking flexible, unidirectionally moving webs on hard surfaced, cylindrical web supports can be considered functionally as comprising basically two types of web supports. The linearly moving web approaching a web support "sees" the support, relative to a fixed frame, either as (1) a laterally constraining support or (2) a laterally non constraining support. A laterally constraining support may be further subdivided into (*a*) an angular lateral constraint in which the entering web is constrained against changing its lateral position, except as its angular position changes, and (*b*) a positional lateral constraint in which the entering web is constrained against changing its spatial lateral position, while remaining free to change its angular position. The web entering a non constraining support, on the other hand, is free to change either its angular or its spatial lateral position without experiencing substantial lateral forces.

Whether a particular web support is a laterally constraining or laterally non constraining support depends as much on its function in the tracking apparatus as on its structure. For example, a rotating fixed-axis cylindrical roller, such as an idler roller or a drive roller in a tracking apparatus, is structurally an angular lateral constraint capable of constraining the moving web against change in its lateral position. To perform functionally as an angular lateral constraint, however, the entering web has to be capable of tracking on the rotating cylindrical surface until the moving web and the rotating surface are in alignment; i.e., until the longitudinal axis of the rotating surface is perpendicular to the direction of travel of the web. This tracking phenomenon is due to frictional forces developed between the linearly moving web and the rotating surface, which in turn are a function of, among other variables, wrap angle, web tension, and the upstream web-span to web-width ratio. Thus, if the wrap angle, for example, is insufficient to create the frictional forces necessary for tracking, the entering web is free to change its angular position and/or its lateral spatial position, without experiencing a constraint imposed by the web support. The web support may therefore be a web support that is functionally non constraining, although structurally an angular lateral constraint.

support that is functionally non constraining, although structurally an angular lateral constraint.

Although the above-noted variables upon which tracking depend are usually parameters which are governed by the design of the web tracking apparatus, some generalities can be stated that cover a significant number of situations. Thus, for a flexible web support by hard surface cylindrical supports, the upstream web-span to web-width ratio should be somewhat equal to or greater than one, and the wrap angle should range between approximately 30° and 135°, depending on the coefficient friction of the surfaces in contact, and on web tension. If otherwise, the web could be prevented from tracking, either because of not enough, or too much contact with the web support.

To facilitate the discussion to follow, it will be convenient to refer to a laterally non constraining support as an N support, and to refer to a laterally constraining support as a P support if it is functionally positional lateral constraint and as an A-support if it is functionally an angular lateral constraint.

In designing a closed loop web tracking apparatus of the type discussed above, one of the primary considerations of the design is lateral stability of the lineraly moving web. Generally, stability of the linearly moving web is achieved if the tracking apparatus has at least two laterally constraining supports, at least one of which is further restricted to be a P-support; the remaining web supports, if any, in the tracking apparatus can be either laterally constraining supports (P and A) or non constraining supports (N) as dictated by design considerations.

Although the stability principle stated above will ensure linear stability of the moving web, it does not, without more, ensure uniformity of tension in the moving web. Non-uniformity in tension ordinarily results from imperfections in the manufacture of webs and web supports, and from the lack of perfect parallelism in the longitudinal axes of the mounted web supports. It follows that if manufacturing tolerances are minimized and the supports are mounted with a high degree of parallelism, a degree of uniformity of tension will be achieved. However, such considerations are independent of the stability principle.

If a high degree of uniformity of tension of the web is a requisite of the tracking apparatus design, it can be achieved with little regard to manufacturing or mounting tolerances by conforming the web tracking apparatus to what will be referred to as the uniformity of tension principle. This second web tracking principle dictates that the moving web exiting from a first laterally constraining support must be given freedom, once and only once, to change direction before entering a second laterally constraining support. This freedom is given to the exiting web by "gimballing" the web support; i.e., by mounting the web support, whether of the constraining type or of the non-constraining type, for pivotal movement about a gimbal axis which is parallel to the direction of linear movement of the entering web, and which intersects the longitudinal axis of the support at the midpoint of the support.

The gimbal action of the web support, i.e., the capability of the exiting web to change direction, enables the exiting web to compensate for non-uniformity of tension of the web in the downstream web span. The resultant force of the non-uniform tension across the

centerline of the moving web; the component of that resultant force which is perpendicular to the gimbal axis creates a moment about the gimbal axis which varies with the sine of the wrap angle, since the magnitude of the force component perpendicular to the gimbal axis varies with the sine of the wrap angle. For example, for wrap angles approaching zero or 180° the magnitude of the force component approaches zero and therefore, the exiting web is not free to change direction.

It is clear from the above relationship that the magnitude of the force component perpendicular to the gimbal axis is greatest for a wrap angle of 90°; moreover, as the wrap angle increases appreciably from 180° the exiting web behaves as if the wrap angle were appreciably greater than zero. While the gimbal action may not be appreciably inhibited by large wrap angles (e.g., those appreciably less than 180° and especially those appreciably greater than 180°), such large wrap angles may inhibit the tracking action of a web support, thereby possibly producing an unstable tracking apparatus.

The "once and only once" requirement of the uniformity of tension principle can be illustrated by theorizing a tracking apparatus in which the web exiting from a first laterally constraining support encounters two N-supports before entering a second laterally constraining support. The "once and only once" requirement provides that only one of the three supports, i.e., the first laterally constraining P- or A-support, the first N-support, or the second N-support, be gimballed; the other two must prevent the exiting web from changing direction. For reasons noted above, gimballing one of the supports provides uniformity of tension in the downstream web without affecting lateral stability. However, if more than one support is gimballed before the web enters a second lateral constraint, the lateral position of the web at the second and any subsequent non-constraining gimballed support, becomes unstable and indeterminate. The result could be lateral instability of the web span between the first gimballed support and the second constraining web support, and possible edge damage to the moving web due to such instability. Thus, the "once and only once" requirement ensures lateral stability in the moving web when N-supports are utilized in a tracking apparatus, while providing uniformity of tension.

Theoretically, the above principles would not be violated by a two-support, closed loop web tracking apparatus. However, technical problems such as the gimballing of a drive roller to meet the "once and only once" requirement, and wrap angle considerations upon which the gimballing action depends, as well as practical problems such as utility for such a two-support apparatus, could make such an apparatus commercially unattractive. The introduction of additional supports to a closed loop web tracking apparatus, however, eliminates such technical and practical problems if the combination of supports conforms to the two tracking principles outlined above, and their location relative to each other is such that the respective wrap angles the moving web makes with the three or more supports are within the limits previously discussed. In particular, a gimballed N-support could be located downstream from the drive roller of a web tracking apparatus (an A-support) to decouple the angularly constrained web tracking apparatus which satisfies both web tracking principles: stability and uniformity of tension in the moving web.

Non-constraining N-supports disclosed by the art include low friction cylindrical non-rotating surfaces, and axially compliant rotating web supports. Such disclosed web supports, however, are not gimballed and, therefore, do not impart angular freedom to the exiting web. The art also discloses web supports in which the rotating cylindrical surface of the web support is mounted for pivotal movement about caster and gimbal axes. For example, U.S. Pat. No. 3,596,817 discloses a web support having a castered and gimballed roller in which the pivotal movement about the caster and gimball axes is achieved by mounting the roller on a multiplicity of flexture arms. This type of mounting, although adequate for some purposes, can be impracticable for others. For example, the available space and load requirements may necessitate a different mounting. Also known are web supports having cylindrical rollers which are rotatably mounted for pivotal movement about a gimbal axis. An example is U.S. Pat. No. 3,608,796 in which the rotating cylindrical roller is mounted for pivotal movement about its midpoint. Such midpoint pivotal movement is reduced to pivot movement about a gimbal axis by a constraining member. However, unlike one that is castered and gimballed, such a web support angularly constrains the entering web; i.e., functionally, it is a gimballed A-support.

Accordingly, it is an object of the present invention to provide a web support having a castered and gimballed web engaging roller mounted on a fixed axis support.

It is another object of the invention to provide a web support in which the castering and gimballing pivotal movement of a web engaging roller is controlled by one external member only.

SUMMARY OF THE INVENTION

These and other objects are accomplished according to the preferred embodiment of the present invention by rotatably mounting a cylindrical web engaging roller on a fixed support for pivotal movement of the roller about its midpoint and for translation movement of the roller along the fixed support while statically and dynamically supporting the roller solely at its midpoint. A single constraining member reduces the movement of the roller to pivotal movement about a gimbal axis and about a castering axis, and to translation movement along the fixed support as required for pivotal movement about the castering axis. The gimbal axis is parallel to the plane of the entering web portion of the moving web and is perpendicular to and intersects the longitudinal axis of the roller. The castering axis is perpendicular to the plane of the entering web at a point upstream from the midpoint of the roller.

In the preferred embodiment, a hollow cylindrical roller is supported on a fixed rigid shaft of uniform cross-section by a self-aligning radial ball bearing upon which the roller is mounted with their respective midpoints coincident. The radial ball bearing enables the roller to rotate about its longitudinal axis and pivot about its midpoint, and is fixedly supported by a bushing mounted about the rigid shaft, thus enabling the roller to translate on the rigid shaft. Alternatively, the roller [illegible]

of flexturally mounted members between the outer surface of the bushing and the inner surface of the roller to achieve the same result.

The pivotal and translational movement in either embodiment is controlled by a constraining arm, defining a line of action, one end of which is mounted to the roller through an outboard bearing for pivotal movement about a pivotal axis. The opposite end of the constraining arm is mounted to a fixed frame for pivotal movement about a pivot point. The line of action corresponds to the centerline of the constraining arm and passes through the pivot point, intersecting the longitudinal axis of the roller at an oblique angle and the gimbal axis at a point upstream from the midpoint of the roller. The pivotal axis is defined by the intersection of and is mutually perpendicular to the line of action of the constraining arm and the longitudinal axis of the roller. A counterweight is mounted at the end of the roller opposite the end upon which is mounted the outboard bearing. The counterweight counterbalances the weight of the outboard bearing and the constraining arm so that the roller is statically and dynamically supported on the fixed shaft solely at its midpoint.

The invention and its objects and advantages will become more apparent from the detailed description of the preferred embodiment presented below.

BRIEF DESCRIPTION OF THE DRAWINGS

In the detailed description of the preferred embodiments of the invention presented below, reference is made to the accompanying drawings, in which:

FIG. 1 is an isometric view of the web support of the invention showing the mounting mechanism for the web transporting roller, which is partly broken away, and the relative location of the various axes;

FIG. 2*a* is a longitudinal cross-sectional view of the web support showing the mounting of the roller;

FIG. 2*b* is a partial side view of the web support with its constraining arm;

FIG. 2*c* illustrates another embodiment of the web support of the invention and shows a roller supporting bushing which is flexurally mounted to the roller at its midpoint for achieving translation along the shaft and pivotal movement about the center of the roller;

FIG. 3*a* illustrates still another embodiment of the web support of the invention and shows a constraining arm having a yoke at one end and a ball and socket arrangement at the other end; and

FIG. 3*b* is a side view of the embodiment of FIG. 3*a* and shows the constraining arm pivotally mounted to the roller outboard bearing for pivotal movement about an axis which intersects the longitudinal axis of the roller.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings wherein like reference numerals have been used in several views and figures for like elements, FIG. 1 illustrates a web support 10 having a castered and gimballed roller 11, in the form a hollow cylindrical drum, mounted according to the invention. As clearly seen in FIGS. 1 and 2*a*, web support 10 further comprises a self aligning radial ball bearing 55 mounted on a ball bushing 56, an outboard bearing 80 fixedly connected to constraining arm 60 through outer ring 82, and a balancing counterweight

Ball bushing 56 is slidably mounted on fixed shaft 51 which is supported by yoke 71, which, in turn, is mounted to fixed frame 53. Bearing 55 is centrally mounted on bushing 56 and roller 11, and is fixed in position to the bushing and the roller, respectively, by locking rings 14 and locking annulus 12 (see FIG. 2*a*). The radial ball bearing in combination with the ball bushing rotatably supports roller 11 solely at is midpoint while simultaneously enabling the roller to pivot about its midpoint and translate along shaft 51. The pivotal and translational movement of roller 11 is relative to fixed frame 53 which may be the frame of a web tracking apparatus such as that disclosed in copending application Ser. No. 504,771.

A constraining arm 60, mechanically connecting roller 11 to yoke 71, reduces the degrees of freedom of movement of roller 11 to pivotal movement about gimbal axis 20 and castering axis 30 without affecting the rotational movement of the roller about longitudinal axis 40. Constraining arm 60 comprises a stiff member 63 to which is mounted at one end a resilient wire 61 and at the opposite end a semi-rigid plate 62. Resilient wire 61 is mechanically connected to yoke 71 by attaching the free end to a member 70 which is adjustably positionable in yoke 71 by screw assembly 72. Plate 62 of constraining arm 60 is bent along a line 64 (FIG. 2*b*) which is perpendicular to and intersects the line of action 66 of constraining arm 60. The portion of plate 62 between bend line 64 and rigid member 63 makes an oblique angle with longitudinal axis 40 of roller 11, whereas the portion between bend line 64 and the end opposite that connected to rigid member 63 is perpendicular to the longitudinal axis of the roller. The significance of the oblique angle will become apparent in the discussion to follow. Further, inspection of FIG. 2*b* will reveal that other side.

The portion of plate 62 which is perpendicular to axis of rotation 40 is mounted to outer ring 82 of outboard bearing 80 by screws 67. It is readily apparent from viewing outboard bearing 80 in cross-section in FIG. 2*a* that roller 11 is free to rotate about its longitudinal axis 40 (which in FIG. 2*a* is coincident with axis 50 of shaft 51) while the inner ring 81 of outboard bearing 80 remains stationary. To offset the added weight of outboard bearing 80 and constraining arm 60 at one end of roller 11, counterweight 52 is added to the opposite end of the roller so that web support 10 is statically and dynamically balanced about the midpoint of roller 11.

From the foregoing it will be seen that constraining arm 60 is free to pivot in any direction at the end comprising resilient wire 61, and free to pivot about pivotal axis 65 only at the end comprising plate 62. The mounting of constraining arm 60 on outboard bearing 80 is such that the line of action 66 of constraining arm 60, pivotal axis 65, and longitudinal axis 40 of roller 11, intersect at a common point. Moreover, pivotal axis 65 is substantially perpendicular to the imaginary plane 45 formed by line of action 66 and longitudinal axis 40 (see FIG. 1) which, for convenience, will be referred to as the entrance plane.

The resultant freedom of movement of roller 11, due to the various mechanical parts of web support 10 described above, is (1) pivotal movement about a gimbal axis 20, lying in the entrance plane 45, which is perpendicular to and intersects longitudinal axis 40 at the midpoint of roller 11; and (2) arcuate movement, having

which is substantially perpendicular to and intersects entrance plane 45 at the intersection between gimbal axis 20 and line of action 66 of constraining arm 60. It is clear that the magnitude of radius 35 is dependent on the oblique angle line of action 66 makes with horizontal axis 40.

Inspection of the geometries of FIGS. 1 and 2*a* will reveal that arcuate radius 35 varies according to the amount of translation of the midpoint of the roller along shaft 51. If translation of roller 10 is toward flexure arm 60, the castering radius becomes longer. If, on the other hand, the translation is away from flexure arm 60, the castering radius becomes shorter. However, for small translations from nominal, the castering radius remains relatively constant to a close approximation. Similarly, the gimbal axis 20 varies slightly from its nominal position. As seen in FIG. 1, and more clearly in FIG. 2*b*, the ends of roller 10 have arcuate motion indicated by arrow 68 rather than straight line motion along pivotal axis 65. This is due to the pivotal action of flexure arms 60. As with variations in arcuate radius 35, for small pivotal movement of roller 10 about axis 20 the ends have linear motion rather than arcuate motion, to a close approximation. These variations from nominal are indicated solely for clarity; they do not limit the function of the web support in any significant way.

In an apparatus incorporating the preferred embodiment of the invention illustrated in FIGS. 1–2*b*, the surface of roller 11 is polished aluminum, the web in contact with roller 11 is polyethylene tenephthalate and has a thickness in the order of 7 mils, the wrap angle of web W around roller 11 is in the order of 120°, the ratio of upstream web span to web width is approximately one, and the web tension of the web W is approximately one-half ounce per inch. It should be noted at this point that web support 10 is unidirectional, i.e., it must be assembled in relation to the entering plane of the web and its direction of travel. As seen in FIGS. 1 and 2*b* the plane of entering web portion 15 of the web is substantially parallel to entrance plane 45, while the direction of travel of the web is such that the castering axis 30, which is substantially perpendicular to the plane of entering web portion 15 of moving web W is upstream of web support 10.

In operation, the fully constrained entering web portion 15 of web W, moving in the direction indicated by arrow 5, does not "see" web support 10 as a lateral constraint since roller 11 will pivot about castering axis 30 until longitudinal axis 40 is perpendicular to the direction of travel of entering web portion 15. That is, through the phenomenon of tracking discussed above, roller 11 will align itself to the entering web portion 15 by pivoting about axis 30 until its longitudinal axis is perpendicular to the direction of travel of the entering web portion. Any pivotal resistance about castering axis 30 imposed by frictional or mechanical forces which would prevent roller 11 from fully aligning itself to the direction of travel of the entering web portion 15 (thus imposing a small lateral constraint on the web), is compensated by providing roller 11 with a low-friction, polished aluminum surface which promotes slippage between the surface of roller 11 and the web in contact with such surface.

It is noted for illustrative purposes, that the alignment of roller 11 to the fully constrained entering web portion of the instant invention is the reverse of what occurs when a moving web, not fully constrained, enters an angularly constraining web support such as a fixed axis, cylindrical drum. In this latter situation, it is the entering web which aligns itself to the web support so that its direction of travel becomes perpendicular to the fixed longitudinal axis of the rotating cylindrical drum.

Exiting web portion 16 of moving web W is given freedom to change its angular direction, thereby angularly decoupling the fully constrained entering web portion 15 of moving web W. This freedom in exiting web portion 16 to change angular direction without affecting the lateral spatial and/or angular position of the upstream entering web portion 15 is due to the capability of roller 11 to pivot about gimbal axis 20 in response to downstream conditions. Although from viewing the arcuate movement of the end of roller 11 indicated by arrow 68 in FIG. 2*b* it may appear that movement of roller 11 about gimbal axis 20 will produce a change in the perpendicularity of longitudinal axis 40 and the direction of travel of entering web portion 15 (which would affect the lateral position of entering web portion 15), closer examination will reveal that roller 11 will automatically compensate for any changes in perpendicularity by simply pivoting about castering axis 30. Thus, exiting web portion 16 is free to change angular direction without affecting the lateral position of the entering web portion 15.

As noted earlier, the surface of roller 11 is polished aluminum and the wrap angle of the web about roller 11 is approximately 120° which is in proper range for tacking and for gimballing. Since it is an N-type support, lateral slippage between roller 11 and the web in contact with roller will be beneficial to the function of the web support, which function is to present no lateral resistance to the entering web.

FIGS. 2*c* through 3*b* illustrate other embodiments of various parts of the invention. FIG. 2*c* illustrates a bushing which is flexurally mounted to the roller to provide the center pivot feature. That is, the pivotal movement of roller 11' about its midpoint is achieved through flexure member 90 rather than self-aligning bearing 55 as shown in FIG. 2*a*. FIGS. 3*a* and 3*b* illustrate the use of a yoke 92 mounted on a ball-and-socket arrangement 85, rather than flexure arm 60 as illustrated in FIG. 2*a*. Ball and socket 85 allows yoke 92 to pivot in any direction. Yoke 92 is pivotally mounted to outboard bearing 80' by pins 93. The centerline of pins 93 intersects the axis of rotation of roller 11'. As in the preferred embodiment, the castering radius and the gimbal axis vary slightly from nominal. However, as noted earlier, this places no apparent restrictions on the function of the web support.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

I claim:

1. In a web support for engaging a fully constrained moving web having an entering portion and an exiting portion relative to such web support, said web support being of the type having a web engaging cylindrical roller which presents no lateral resistance to such entering web portion and which angularly decouples such exiting web portion, the improvement which comprises:

b. means for mounting said roller on said fixed support to statically and dynamically support said roller solely at a midpoint, and to provide for rotational movement of said roller about a longitudinal axis, pivotal movement of said roller about said midpoint, and translational movement of said roller along said fixed axis; and

c. means for constraining said pivotal and translational movement of said roller to pivotal movement about a gimbal axis perpendicular to and intersecting said longitudinal axis at said midpoint of said roller and extending in a plane substantially parallel to such entering web portion, pivotal movement about a castering axis substantially perpendicular to such entering web portion and intersecting said gimbal axis at a point upstream from said midpoint of said roller, and translational movement along said fixed axis as required for pivotal movement about said castering axis.

2. The invention of claim 1 wherein said fixed support is a rigid shaft of uniform cross-section.

3. The invention of claim 1 wherein said roller mounting means includes a radial ball bearing having a midpoint coincident with said midpoint of said roller for enabling said roller to pivot about its midpoint, and a bushing about said rigid shaft for fixedly supporting said radial ball bearing, and for enabling said roller to translate along said shaft.

4. The invention of claim 1 wherein said roller mounting means includes a flexure member having a midpoint coincident with said midpoint of said roller for enabling said roller to pivot about its midpoint.

5. The invention of claim 1 wherein said constraining means includes:

a. an outboard bearing mounted at one end of said roller;

b. a constraining arm, defining a line of action, one end of which is mounted to said roller through said outboard bearing for pivotal movement about a pivotal axis, the end opposite said one end of which is mounted to a fixed frame for pivotal movement about a pivot point, said line of action passing through said pivot point and intersecting said longitudinal axis at an oblique angle and said gimbal axis at an upstream location, said pivotal axis being defined by the intersection of and being mutually perpendicular to said line of action and said longitudinal axis; and

c. a counterweight mounted at the end opposite said one end of said roller for counterbalancing said outboard bearing and said constraining arm to statically and dynamically balance said roller solely at its midpoint.

* * * * *

United States Patent

[11] 3,608,796

[72] Inventors John E. Morse;
Richard A. Marsh, both of Rochester, N.Y.
[21] Appl. No. 873,565
[22] Filed Nov. 3, 1969
[45] Patented Sept. 28, 1971
[73] Assignee Eastman Kodak Company
Rochester, N.Y.

[54] WEB-SUPPORTING DEVICE
11 Claims, 2 Drawing Figs.

[52] U.S. Cl. 226/21, 226/194
[51] Int. Cl. B65h 25/26
[50] Field of Search 226/180, 190, 194, 21, 23; 74/241; 198/202

[56] References Cited
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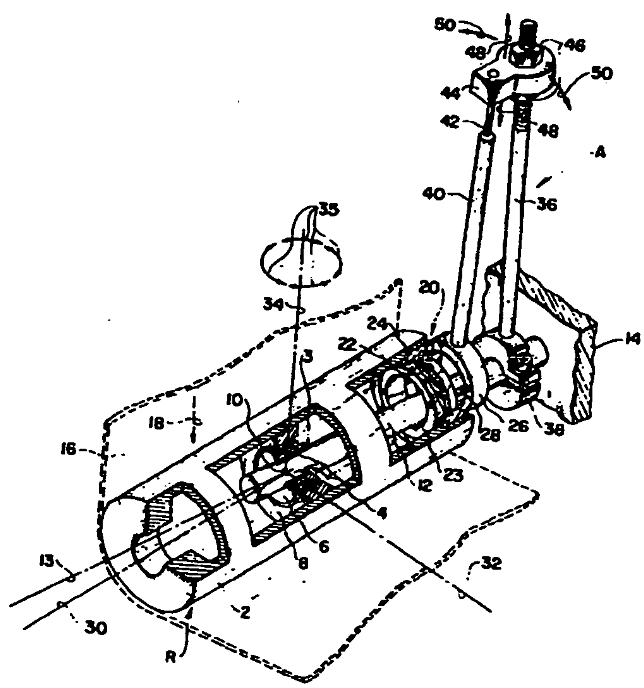
Primary Examiner—Richard A. Schacher
Attorneys—Robert W. Hampton and Gary D. Fields

ABSTRACT: A supporting roller across which a flexible web moves is rotatably mounted at its midpoint on a longitudinal shaft and is pivotally movable with respect to said shaft. Three orthogonal axes pass through the midpoint. The first axis is the longitudinal aXis of the roller; the roller is adjustably positionable about the second axis; and the third axis is a gimbal axis about which the roller is free to rotate. In order to restrain the roller for these movements one end of the roller is provided with a roller bearing which is connected by flexures to an annulus extending around the shaft. In one embodiment the annulus is connected by a flexure arm to a lug which is longitudinally adjustable along a support post extending perpendicular from the shaft. Also, the post is adjustably positionable about the shaft so that the direction of the gimbal axis can be changed. In another embodiment a spring bracket biases the flexure member along its axis, the amount of the movement thereof being limited by a setscrew.



PATENTED SEP 28 1971 3,608,796

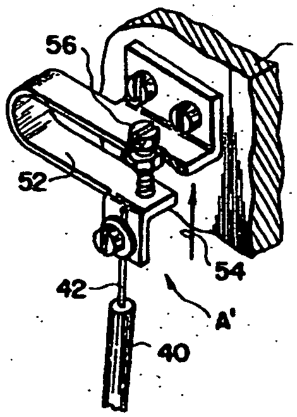


FIG. 2

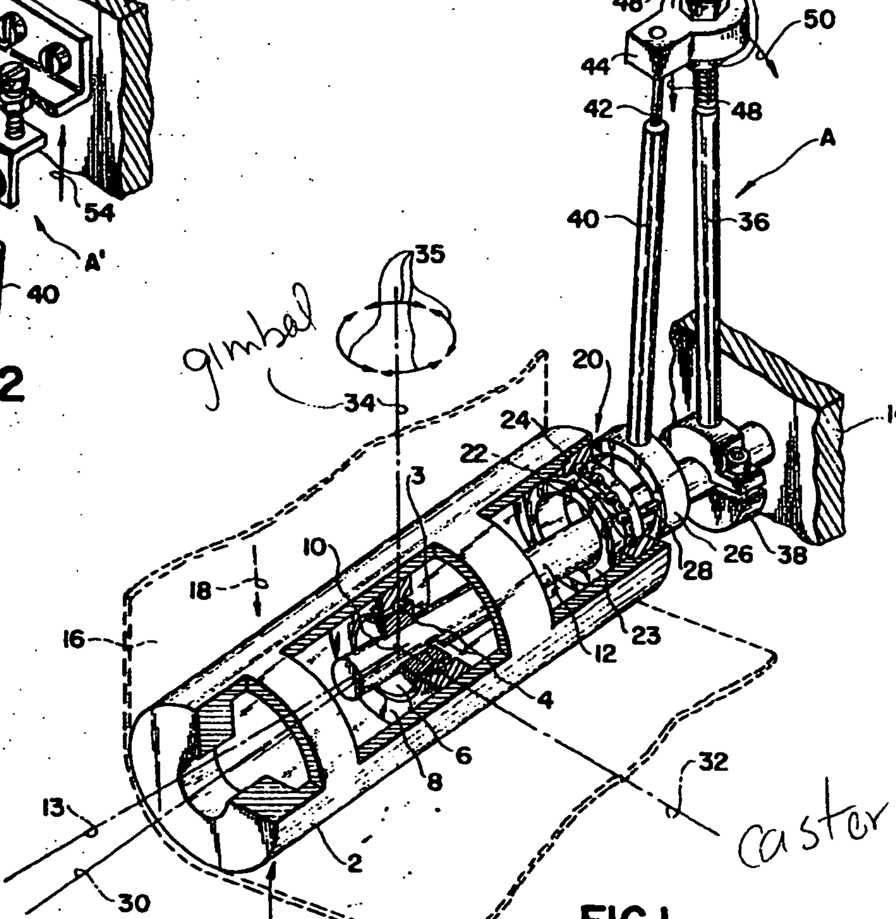


FIG. 1

biased in the ~~od~~ caster direction

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WEB-SUPPORTING DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a web-supporting device and more particularly to an adjustably positioned roller which is pivotal about a gimbal axis passing through the midpoint of the roller.

2. Description of the Prior Art

Various attempts have been made in the prior art to provide guides and suitable constraints for flexible belts or webs which are fed from a supply roll to a takeup roll. Also, similar devices have been provided for endless belts. Idler rollers have been provided which are self-aligned by a belt or web which tends to run off one side of the roller. To provide even tension across the belt, rollers have been mounted for pivotal movement about a center point, as disclosed in commonly assigned U.S. Pat. No. 3,161,283 to Knab et al. which issued Dec. 15, 1964; U.S. Pat. No. 3,315,859 to Owen et al. which issued Apr. 25, 1967; and U.S. Pat. No. 3,342,389 which issued to Drexler on Sept. 19, 1967. In each of these devices means are provided at the edge of the roller for sensing misalignment of the belt causing the roller to pivot in such a way as to correct this misalignment. Such arrangement can result in damage to the edge of the web and in an unstable system whereby the web is continually wandering back and forth across the roller. In a web path, where a web is subject to both upstream and downstream constraints, it is desired that the roller provide a stable adjustable lateral position of the web without imposing nonuniform stresses on the web.

SUMMARY OF THE INVENTION

In the present invention a flangeless support roller for a web is mounted for rotational and pivotal movement about a midpoint, but the roller is further restrained for movement about only one of three orthogonal axes passing through the roller. One of these axes is the longitudinal axis of the roller. The second orthogonal axis is the axis about which the roller is to be adjusted, and the third orthogonal axis is the axis about which the roller is free to rotate. This latter axis will be referred to as the gimbal axis. Thus, by providing means for adjusting the direction of the longitudinal roller axis with respect to the web about the second axis and for allowing the longitudinal roller axis to be free about the third or gimbal axis, a tracking roller is provided which allows adjustment of the lateral web position at the roller and imposes the proper restraints on the web without imposing additional unwanted restraints.

This is accomplished in the present invention by providing means at one end of the roller for adjustably positioning a longitudinal axis of the roller about the second orthogonal axis and for positioning the direction of the second and third orthogonal axes with respect to the web. In one embodiment this adjustment means includes an annulus surrounding a longitudinal shaft which is nominally parallel to an approach and an exit plane of the web and is connected to a roller bearing at one end of the roller for adjustably positioning the roller. The annulus in turn is connected to a flexure arm extending substantially perpendicularly from the longitudinal axis. A support post extends perpendicularly from the longitudinal shaft and is provided with means connected to the flexure arm for adjustably positioning the latter with respect to the longitudinal shaft. In addition, the post is adjustably mounted for pivotal adjustment about the longitudinal shaft to adjustably position the direction in which the second and third orthogonal axes lie with respect to the web. Conveniently, a counter balance is provided at the opposite end of the roller to counter balance the weight of the bearing, annulus and flexure arm at the opposite end.

In an alternative embodiment, the flexure arm is connected to a biasing bracket which exerts a longitudinal force on the flexure member and has a setscrew which limits the amount of movement that can be imposed upon the flexure member and hence on the end of the roller.

There are at least two uses for rollers constructed in accordance with this invention: If the gimbal axis is substantially parallel to the direction of the web approach plane, the roller can be used with a web which is laterally constrained upstream and angularly constrained downstream or it can be used with a web which is laterally constrained upstream and laterally constrained downstream. When so used, the roller maintains a stable adjustable lateral position for the web at the roller location and does not cause uneven tension distribution in the entering or leaving web sections.

Additional advantages of this invention will become apparent from the description which follows, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of one form of the present invention, with parts broken away for clarity of illustration; and

FIG. 2 is a fragmentary perspective view of an alternative gimbal axis adjustment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In accordance with this invention, a roller assembly R includes a roller 2, as shown is mounted for rotation and pivotal movement in a bearing member 3 having ball bearings 4 mounted between an inner race 6 and slightly loose outer race 8 at the midpoint 10 of the roller. Inner race 6 is fixedly connected to a shaft 12, having an axis 13 and extending from a frame or base 14 of the apparatus in which the tracking roller is used.

Roller 2 is adapted to support a web 16, which may move in the direction of arrow 18 and engages roller 2 along an approach plane and departs therefrom along an exit plane as shown. Roller support shaft 12 is nominally mounted so as to be generally parallel with both the approach and exit plane of web 16. However, in actual practice it is virtually impossible to provide such a precise alignment of shaft 12. Therefore, to compensate for any misaligment, means must be provided for adjusting the position of roller 2 with respect to shaft 12 so that it causes the web to seek the desired lateral position without imposing any unwanted constraints on web 16 as it passes thereacross.

To accomplish this, bearing assembly 20 is provided which includes ball bearings 22 between an inner race 23 and an outer race 24; fixedly connected to the roller. Conveniently, outer race 24 is fixedly mounted in the end of the roller and the inner race 23 is free to rotate therein. A roller adjustment assembly A is provided which in this embodiment includes an annulus 26 extending around shaft 12 adjacent bearing assembly 20 and is connected to inner race 23, as by a pair of flexure members at opposite sides thereof, such as flexure member 28.

Three orthogonal axes pass through midpoint 10 about which movement or position of roller 2 is important. These axes are roller axis 30, adjustment axis 32, and gimbal axis 34. Through roller adjustment assembly A, the roller is constrained so that it is free to rotate about gimbal axis 34, as illustrated by arrows 35, but is adjustably positionable with respect to adjustment axis 32. To provide this adjustment, an adjustment post 36 extends perpendicularly from shaft 12 and is attached thereto by a clamp 38. A flexure arm 40 extends from annulus 26 and has a reduced portion 42 which serves as a pivot by which flexure arm 40 is attached to a lug 44. Lug 44 is adjustable along post 36 by means of spaced adjustment nuts 46. By this means the end of roller 2 is moved in the direction of arrows 48 to adjustably position the roller about axis 32. The direction of gimbal axis 34 can be adjusted with respect to the approach and exit planes of the web by means of clamp 38 which may be loosened to rotate post 36 about shaft 12 in the direction of arrows 50. The weight of bearing assembly 20, annulus 26 and flexure arm 40 is counterbalanced conveniently by thickened portion 51 at the opposite end of roller 2.

Castor axis

It will be noted that reduced section 42 of flexure 40 serves as a pivot point to permit rotation of roller 2 about gimbal axis 34 without interference from the roller adjustment assembly A. Also, flexures 28 permit pivotal movement of roller 2 about adjustable axis 32 as adjustment lug 44 is moved through its adjustment range. However, after adjustment, the position of roller 2 about axis 32 is fixed.

An alternative adjustment assembly A is shown in FIG. 2 wherein the reduced end 42 of flexure 40 is attached to a U-shaped spring bracket 52 which in turn is attached to frame or housing 14 as shown. Spring bracket 52 exerts a force on flexure 40 in the direction of arrow 54. The extent of movement of flexure 40 is limited by an adjustable setscrew 56.

From the foregoing, the advantages of this invention are readily apparent. A web-handling device is provided which facilitates free movement of the roller about a gimbal axis extending through the midpoint of the roller, but the roller is adjustably fixed about an adjustment axis which is perpendicular to the gimbal axis and to the longitudinal axis of the roller. Thus, the longitudinal axis of the roller can be positioned so as to be exactly perpendicular to the desired web approach direction and the direction of the gimbal axis may be adjusted to be substantially parallel with the web approach plane as desired for the particular use for which the roller is to be put depending on the upstream and downstream constraints already exerted on the web.

The invention has been described in considerable detail with reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

We claim:

1. A web-tracking device for transporting a web between upstream and downstream constraints and having first, second and third orthogonal axes, said web being adapted to come into engagement with said tracking device along an upstream approach direction, said device comprising:
- means defining a fixed longitudinal axis;
- a roller for supporting a web, said roller having two ends and a midpoint and being rotatably supported solely at said midpoint for rotation about said fixed axis said orthogonal axes extending through said midpoint, wherein said first orthogonal axis is said roller axis and is normally coincident with said fixed axis; and
- means for constraining said roller for free pivotal movement about said third orthogonal axis as a gimbal axis and for adjustment of said roller axis about said second orthogonal axis so that said roller axis is substantially perpendicular to said approach direction.

2. A web-tracking device as claimed in claim 1 wherein said constraining means includes:
- means connected to one end of said roller adjustably movable in a direction perpendicular to said fixed axis to adjustably position said roller about said second orthogonal axis.

3. A web-tracking device for transporting a web between upstream and downstream constraints and having first, second and third orthogonal axes, said web being adapted to come into engagement with said handling device along an upstream approach direction, said device comprising:
- a fixed shaft having a longitudinal axis;
- a roller for supporting a web, said roller having first and second ends and a midpoint through which said orthogonal axes extend, said first orthogonal axis being said roller axis;
- mounting means concentrically arranged with respect to said midpoint as the sole means for rotatably mounting said roller on said shaft so that said roller axis if free to pivot in all directions about said midpoint, being unsupported at said first and second ends;
- first adjustable positioning means for adjustably fixing the position of said roller axis about said second orthogonal axis so that said roller axis is substantially perpendicular to said upstream approach direction without restraining movement of said roller about said third orthogonal axis.

4. A web-tracking device as claimed in claim 3, further including:
- second adjustable positioning means for adjustably positioning said orthogonal axes about said longitudinal axis.

5. A web-tracking device as claimed in claim 3, wherein said first adjustable positioning means includes:
- a bearing rotatably attached to said first end of said roller;
- means connected to said bearing for adjustably locating said one end of said roller transversely with respect to said shaft.

6. A web-tracking device as claimed in claim 5, further including:
- counterbalance means on said second end of said roller to counterbalance said bearing.

7. A web-tracking device as claimed in claim 5, wherein said adjustable locating means includes:
- an annulus extending around said shaft and connected to said bearing;
- an arm, having a longitudinal axis, extending from said annulus;
- means biasing said arm along said longitudinal axis thereof; and
- means limiting the movement of said arm in response to said biasing means.

8. A web-tracking device as claimed in claim 5, wherein said locating means includes:
- an annulus extending around said shaft and connected to said bearing:
- a support post spaced from said annulus and extending perpendicularly from said shaft;
- an arm extending from said annulus;
- adjustment means on said post connected to said arm for positioning said one end of said roller with respect to said shaft.

9. A web-tracking device as claimed in claim 8, further including:
- adjustable clamp means for adjustably connecting said post about said shaft.

10. A web-tracking device as claimed in claim 8, further including:
- first means pivotally connecting said annulus to said bearing; and
- second means pivotally connecting said arm to said adjustment means.

11. A web-tracking device as claimed in claim 10 wherein said first and second means are flexure members.

and being rotatable about the pin second end, the rotation of the tension adjustment disc in a first rotating direction compresses the compression spring and increases the tension applied by the steering roller to the endless belt.

13. The apparatus of claim 12, the compression spring having a second spring end, the belt tensioning means further comprising a tension release cam operatively coupled to the second spring end, the tension release cam being rotatable about a cam axis from an tension-engaging position and a tension-releasing position.

14. The apparatus of claim 13, the belt forming a belt loop within which the steering roller, the carriage means, the belt-tensioning means, and the tension-balancing means are positioned.

15. The apparatus of claim 11, the carriage center member having a coupling hole, the tension balancing means comprising:

a carriage coupling member connected to the pin first end and positioned around a portion of the carriage center member; and

a carriage coupling pin connected to the carriage coupling and passing through the carriage coupling hole, the coupling pin and the carriage coupling hole sharing a tension-balancing axis about which the carriage center member and the steering roller are rotatable.

16. The apparatus of claim 15, the tension-balancing axis being perpendicular to the roller axis and to the steering axis, the tension-balancing axis intersecting the steering axis, the tension-balancing axis not intersecting the roller axis.

17. An apparatus useful for maintaining an endless belt within a lateral target belt position range while the endless belt is transported by a transporting mechanism, the endless belt having a belt inner surface and a first belt edge, the apparatus comprising:

a steering roller contacting the belt inner surface, the steering roller having a first roller end;

carriage means for supporting the steering roller, the carriage means being pivotable about a steering axis such that the steering roller is pivotable about the steering axis;

a first member positioned adjacent to the first roller end and functionally connected to the carriage means, the first member contacting the belt inner surface when the first belt edge extends sufficiently beyond the first roller end, the first member applying greater friction to the endless belt than the steering roller when the belt contacts the first member, the first member being positioned relative to the steering axis such that contact between the first member and the belt causes the first member to apply a first torque to the carriage means about the steering axis; and

pivot-resisting means for resisting the pivoting of the steering roller about the steering axis.

18. An apparatus useful for maintaining an endless belt within a lateral target belt position range while the endless belt is transported by a transporting mechanism, the endless belt having a belt width, a belt inner surface, and a first belt edge, the apparatus comprising:

a steering roller contacting the belt inner surface, the steering roller having a first roller end;

carriage means for supporting the steering roller, the carriage means being pivotable about a steering axis such that the steering roller is pivotable about the steering axis;

a first member positioned adjacent to the first roller end and functionally connected to the carriage means, the first member contacting the belt inner surface when the first belt edge extends sufficiently beyond the first roller end, the first member applying greater friction to the endless belt than the steering roller when the belt contacts the first member, the first member being positioned relative to the steering axis such that contact between the first member and the belt causes the first member to apply a first torque to the carriage means about the steering axis;

a belt tensioning means for causing the steering roller to apply a tensioning force against the belt inner surface; and

a tension balancing means for allowing the belt tensioning means to balance the tensioning force across the belt width.

19. An apparatus useful for maintaining an endless belt within a lateral target belt position range while the endless belt is transported by a transporting mechanism, the endless belt having a belt inner surface and a first belt edge, the apparatus comprising:

a steering roller contacting the belt inner surface, the steering roller having a first roller end;

carriage means for supporting the steering roller, the carriage means being pivotable about a steering axis such that the steering roller is pivotable about the steering axis;

a first member positioned adjacent to the first roller end and functionally connected to the carriage means, the first member contacting the belt inner surface when the first belt edge extends sufficiently beyond the first roller end, the first member applying greater friction to the endless belt than the steering roller when the belt contacts the first member, the first member being positioned relative to the steering axis such that contact between the first member and the belt causes the first member to apply a first torque to the carriage means about the steering axis; and

a tension roller positioned adjacent to the steering roller, the tension roller applying a tensioning force to the belt inner surface.

20. An electrophotographic system, comprising:

an endless belt having a first belt edge, a belt inner surface, and a belt outer surface, the belt outer surface comprising a photoreceptive substrate;

a charging system for charging the photoreceptive substrate;

an exposure system for exposing the photoreceptive substrate to at least one image-wise pattern of radiation which creates at least one electrostatic image on the photoreceptive substrate;

a development system for developing the at least one electrostatic image to an at least one toned image;

a transfer system for transferring the toned image to a receptor; and

a belt-steering system for steering the belt, comprising:

a steering roller contacting the belt inner surface, the steering roller having a first roller end;

carriage means for supporting the steering roller, the carriage means being pivotable about a steering axis such that the steering roller is pivotable about the steering axis;

a first member positioned adjacent to the first roller end and functionally connected to the carriage means, the first member contacting the belt inner surface when the first belt edge extends sufficiently beyond the first